About NCERA-125 and State Reports

NCERA-125 Mission Statement

Insect and weed pests have significant negative impacts on natural and managed ecosystems in the North Central region. Conventional management tools including pesticides are frequently expensive and may have undesirable environmental or human health impacts. Biological control is a critical part of IPM aimed at safe and effective management of pests. The goal of NCERA-125 is to coordinate biological control research, education, and implementation in the North Central Region.

NCERA-125 Objectives

1. Advance the science of biological control through fundamental research on the biology of natural enemies and their application in pest management.

2. Facilitate the implementation of biological control in production and natural systems.

3. Educate stakeholders, students, extension personnel and the general public on the principles and practices of biological control.

4. Contribute to national dialog about regulatory issues of biological control.

About State Reports

Your NCERA-125 State Report serves two functions. It helps inform others about the biological-control related projects in your program and elsewhere in your State (e.g., other projects in your department, or in other educational or government institutions in your state). Information from your report also provides data for the NCERA-125 Annual Report and for the various governmental project reviews and applications for project renewal. By reporting specific accomplishments and impacts we help ensure the future continuance of this working and information-sharing group. Please supply the following information in the new NCERA-125 State Report format.

Illinois

State Representatives: Leellen Solter
Illinois Natural History Survey
lsolter@uiuc.edu

Part I

Accomplishments

1. *Advance the science of biological control through fundamental research on the biology of natural enemies and their application in pest management.*

   b. List citations for your peer-reviewed publications (published this year) on biological control-related research. (Other types of publications will be included below)

   *Hoch, G., D'Amico, V.D., Solter, L.F., Zubrik, M., McManus, M.L. 2008. Quantifying horizontal transmission of a microsporidian pathogen of the gypsy moth, *Lymantria dispar* (Lep., Lymantriidae) in field cage studies. J. Invertebr Pathol. 99, 146-150

   *Solter, L.F. and Hajek, A.E. 2008. Control of gypsy moth, *Lymantria dispar,* in North America since 1878. *In* "Use of Microbes for Control and Eradication of Invasive Arthropods [Hajek, A.E., O'Callaghan, M. and Glare, T., Eds] Springer Publ. Co. pp. 181-212.

   ***In press on last report**

Part II

State Project Summaries

1. **Project title:** Taxonomy and biology of lymantriid microsporidia
   Investigators: L. F. Solter, Illinois Natural History Survey; M. L. McManus and Vince D"Amico, USDA Forest Service, Hamden, CT; D. K. Pilarska, Bulgarian Academy of Sciences, Sofia, Bulgaria; A. Linde, Fachhochschule Eberswalde, Eberswalde, Germany; W.F. Huang, Illinois Natural History Survey. **Contact:** Leellen F. Solter (lsolter@uiuc.edu).

   Summary: *Nosema lymantriae* and *Vairimorpha disparis,* both pathogens of the gypsy moth, were released in May 2008 against gypsy moth in Northern Illinois. A preliminary monitoring collection found high mortality rates due to the fungal pathogen *Entomophaga maimaiga* (originating from Japan and moving west in gypsy moth populations). High mortality due to the fungal pathogen also occurred in 2009. Laboratory examinations of collected larvae in the release sites are being evaluated.

The microsporidia release study is also being carried out in Bulgaria with the same two species of microsporidia. The microsporidia are native to Bulgaria but gypsy moth populations in the chosen sites were uninfected at the time of release. 2009 monitoring in these sites shows persistence of the microsporidian pathogens.

2. **Project title:** Role of Pathogenic Microsporidia in the Hemlock Woolly Adelgid Natural Enemy Complex
Investigators: L. Solter, Illinois Natural History Survey; B. Onken, USDA Forest Service NA, Morgantown, West Virginia; R. Reardon, USDA Forest Service FHTET, Morgantown West Virginia; S. Salom, Virginia Polytechnic State University; M. Montgomery, USDA Forest Service NERS, Hamden, CT; C. Cheah, CT Agriculture Experiment Station, Hamden, CT; M. Baker, Iowa State Univ.; W.F. Huang, Illinois Natural History Survey. **Contact:** Leellen F. Solter (lsolter@uiuc.edu)

   Summary: Microsporidia continue to be found in laboratory colonies of *Sasajiscymnus tsugae,* a coccinellid predator of the hemlock woolly adelgid, *Adelges tsugae*, but instituted culling procedures have lowered prevalence. It was recommended that high prevalence colonies not be released in the field in 2008. No new infections were found in other predatory species, however host specificity studies determined that *Laricobius nigrinus*, *L. osakensis*, and *Scymnus sinuanodulus* were susceptible to the microsporidium in laboratory inoculations. *S. ningshaninsis* was not infected. The microsporidium was sequenced and found to be closely related to *a Drosophila* pathogen. A species description is in progress.

3. **Project title:** A microsporidium of the black vine weevil, *Otiorhynchus sulcatus*
Investigators: D. Bruck, USDA Forest Service, Corvallis, OR; L. Solter and W.F. Huang, Illinois Natural History Survey. **Contact:** Leellen F. Solter (lsolter@uiuc.edu)

   Summary: A virulent microsporidium found in an Oregon population of the black vine weevil, *Otiorhynchus sulcatus,* is being described. Sequence data and transmission electron microscopy show it to be a monokaryotic microsporidium near the *Nosema/Vairimorpha* clade (a dikaryotic group).

4. **Project title:** Biological Control of Lythrum salicaria (Purple Loosestrife) & Education Outreach
Investigators: S. Post, Illinois Natural History Survey and R. Wiedenmann, University of Arkansas. **Contact:** S. L. Post (spost@inhs.uiuc.edu)

   Summary: Even though our rearing and release program for *Galerucella calamariensis* and *Galerucella pusilla*, has ceased there is still interest in the project. Two college lectures were given, one in the Chicago area and one here in Champaign about the loosestrife project and how citizens were involved.
   Using the book *Aliens from Earth* by Beverly Doyle, exotic invasives were one of the lectures for educators (K-8) obtaining a masters in math and science education. As a result several of the educators turned in exotic species lesson plans for the upcoming school year. In Illinois, while our Master Naturalist Program sponsored by the County Cooperative Extension, does not have exotic invasives as one of the required subjects to be taught. I have

spoken to groups in 4 of the 8 counties that have the program. Using materials we developed for our Loosestrife Education project and new weed handouts from the Cooperative Agriculture Pest Survey lively discussions have resulted. I am in contact with the curriculum development team for an "official' unit on Exotic Invasives.

5. **Project title**: Demography of *Alliaria petiolata* (garlic mustard): implications for its biological control
   Investigators: A.S. Davis, USDA-ARS (Urbana, IL); S. Raghu, Brisbane, Austrailia; S.L. Post, Illinois Natural History Survey**. Contact:** S.L. Post (spost@inhs.uiuc.edu)

   Summary: In anticipation of biological control agents being available in the near future, a network of demographic plots has been set-up in Illinois to investigate the pre-biocontrol population dynamics of garlic mustard. We have finished gathering preliminary data are waiting for agents to be approved.

6. **Project Title:** The effects of fertilization and time of cutting on regeneration and seed production of *Dipsacus laciniatus* (Dipsacacae)
   Investigators: Dudly, M.P., J.A.D. Parrish, S.L. Post, C.G. Hem, and R.N. Wiedenmann.
   Published: 2009. Natural Areas Journal 29: 140-145.

7. **Project title:** Cold stratification requirements for germination of *Alliaria petiolata*.
   Investigators: Raghu, S. and Susan L Post.
   Published: 2008. Invasive Plant Science and Management 1: 315-318.

Iowa

State Representatives: Matt ONeal
Iowa State University

Part I

Accomplishments

1. Advance the science of biological control through fundamental research on the biology of natural enemies and their application in pest management.

b. List citations for your peer-reviewed publications (published this year) on biological control-related research. (Other types of publications will be included below)

Schulte, L.A., H. Asbjornsen, R. Atwell, C. Hart, M. Helmers, T. Isenhart, R. Kolka, M. Liebman, J. Neal, M.E. ONeal, R. Schultz, S. Secchi, J. Thompson, M. Tomer, and J. Tyndall. 2008. Targeted conservation approaches for improving water quality: multiple benefits for expanded opportunities. PMR 1002. Iowa State University Extension, Ames IA.

Gardiner, M.M, D.A. Landis, C.D. DiFonzo, C. Gratton, M.E. O'Neal, J. Heimpel, M. Wayo, N. Schmidt, E. Mueller, and J. Chacon. 2009. Landscape diversity impacts biocontrol services in north-central U.S. soybean. Ecological Applications. 19: 143-154.

Gardiner, M.M, D.A. Landis, C. Gratton, N. Schmidt, M.E. O'Neal, E. Mueller, J. Chacon, G.E. Heimpel, M. Wayo, and C.D. DiFonzo. 2009. Landscape composition mediates coccinellid community structure. Diversity and Distributions. 15: 554-564.

Ohnesorg, W., Johnson, K.D, and M.E. O'Neal. 2009. Impact of reduced-risk insecticides on soybean aphid and associated natural enemies. J. Econ. Entomol. 102: 1816-1826

Part II

State Project Summaries

1. Project title: Landscape Affects on Soybean Aphid and Natural Enemy Abundances in Iowa

Investigators: Nicholas Schmidt., Matthew O'Neal[1], and Lisa Schulte[2] 1) Department of Entomology 2) Natural Resource Ecology and Management, Iowa State University, Ames Iowa

Summary: Since the introduction of soybean aphids *Aphis glycines* Matsumara (Hempitera: Aphididae) to North America evidence suggests that natural enemies can negatively impact their populations. In Iowa soybean aphid outbreaks typically occur in odd numbered years, until 2008 when a large portion of the state experienced populations well over the economic injury level. These outbreaks are thought to occur due to increased overwintering success, which results in high immigration rates and ultimately allows aphids to overwhelm the functional and numerical responses of natural enemies. From 2006 – 2009 both soybean aphid and natural enemy data were collected at 109 commercial fields using field-counts (*in situ* sampling), yellow-sticky cards, and sweep-net samples. Our goal is to determine how landscape heterogeneity impacts the soybean aphid and it's natural predator community. The study site was located in and around the Neal Smith National Wildlife Refuge (NSWR) located in the Southwest corner of Jasper County, Iowa. The NSWR is the largest reconstructed tallgrass prairie in the U.S. with >5,000 acres planted. In each year approximately 30 soybean fields in and surrounding the refuge were sampled with visual-counts, yellow-sticky cards, and sweep-net samples each week from June – September. The objectives of the research are to determine if natural enemies respond to increased soybean aphid densities and whether a reduction of natural enemies has occurred. We hypothesize that increased soybean aphid densities will result in increased natural enemy populations. However, data suggests the abundance of aphid predators dramatically declined in 2008 and again in 2009 (with field-counts), potentially due to an increase in disturbances (i.e. seed treatments, herbicide and insecticide applications) and/or abiotic factors (i.e. weather), resulting in altered food-webs. Peak populations of *A. glycines* averaged 204 aphids per plant or < 1,000 CAD in 2006, 370 aphids per plant or 3,472 CAD in 2007, 993 aphids per plant or 7,653 CAD in 2008, and 1,490 aphids per plant or 4,480 CAD in 2009. The peak in the total number of natural enemies observed in field-counts for years 2006 – 2009 was approximately 3.8, 4.9, 0.5, and 0.9 natural enemies per week. The peak in the total number of natural enemies' captured in sweep-nets for years 2006 – 2009 was approximately 4.3, 11.0, 3.2, and 11.0 natural enemies per week. The peak in the total number of natural enemies' captured on yellow-sticky cards for years 2006 – 2009 was approximately 7.9, 4.8, 16.6, and 19.6 natural enemies per week.

2. **Project:** Can reduced-risk insecticides prevent soybean aphid outbreaks?
Investigators: Adam J. Varenhorst and Matthew O'Neal, Iowa State University, Ames, IA

Summary: Insecticide use in soybeans has increased with the establishment of the soybean aphid, *Aphis glycines* Matsumura (Hemiptera: Aphididae) in North America. The insecticides used in soybeans are broad-spectrum which reduce the population of natural enemies that feed on *A. glycines*. As the frequency of insecticide applications increases in soybeans, there is the potential that *A. glycines* outbreaks will become worse. We are exploring if insecticides toxic to *A. glycines* with limited impact on beneficial insects conserve natural enemies and reduce the risk of resurgence of *A. glycines* later in the growing season. Within this field-experiment we are evaluating three insecticides, esfenvalarate a broad-spectrum insecticide commonly used against *A. glycines* and two reduced-risk insecticides; imidacloprid and spirotetramat. Spirotetramat inhibits lipogenesis in Hemipterans and has been shown to have limited impact on beneficial insects. We will evaluate the impact of the later two alone and combined. All insecticides will be applied based on the economic threshold for *A. glycines*.

We will evaluate the impact of these insecticides on *A. glycines* and its associated predators throughout the growing season. In addition, we will measure if conservation of natural enemies by these products results in greater predation of *A. glycines* later in the season. This would result in a greater suppression by a reduced-risk than broad-spectrum insecticide later in the season. This has been observed for reduced-risk insecticides used against *Bemesia tabaci*, and has been referred to as a bioresidual. We will discuss if a bioresidual is possible for the management of *A. glycines*.

3. **Project:** Biocomplexity of integrated perennial-annual agroexosystems
Investigators: Rene Cooklin[1], and Matthew O'Neal[1], Schulte, L.A. [2], H. Asbjornsen[2], M. Helmers[3], M. Liebman[4], M. Harris[1], and J. Tyndall[1]. [1]Department of Entomology, Natural Resources and Environmental Management, Agricultural and Biosystems Engineering, Agronomy: Iowa State University, Ames Iowa,

Summary: Currently, 5,000 acres out of a set goal of 8,654 acres of prairie has been restored at the Neal Smith Wildlife Refuge in Jasper County. Research has been underway for many years to quantify the benefits of these conservation efforts in an attempt to provide strong arguments for habitat restoration of prairie, and especially in crop systems. The benefit of insect biodiversity within agroecosystems is important for several ecological services. Such services include nutrient recycling, pollination, competition (non-pest insects that occupy the same niche a pest insect would keep pest insects below economic injury levels), and predation of pest insects through natural enemies. We are concentrating on the effect that the perennial buffer strips has on the natural enemy population within crop systems at the Neal Smith Wildlife Refuge. Within replicated watersheds, the following treatments were constructed; no perennial habitat within the watershed, 10% of the watershed at base in perennial habitat, 10% of the watershed in perennial habitat in the base and strips, and 20% of the watershed in perennial habitat in the base and strips. The perennial habitat within the experimental watersheds contained reconstructed prairie buffers that were sampled monthly using a sweepnet. Three random spots within each perennial strip and soybean plot were sampled, and separated according to site and repetition. Results are still being processed, but abundance of three aphid predators (Syrphidae, Neuroptera, and Coccinellidae) indicate a tendency for the perennial strips to affect the natural enemy populations that are adjacent in soybean row crops. In August, when the soybean aphid populations reached high population within soybean fields, natural enemy abundance was reduced in the perennial strips.

4. **Project title**: Releasing *Binodoxys communis* for soybean aphid suppression
Investigators: Rene Cooklin and Matthew O'Neal, Department of Entomology, Iowa State University, Ames Iowa.

Summary: As part of greater effort by colleagues across the mid-west, the Soybean Entomology Laboratory at Iowa State University is releasing *Binodoxys communis* in soybean fields and buckthorn stands.

Kansas

State Representatives: J. P. Michaud and Jim Nechols
Kansas State University
jpmi@ksu.edu, jnechols@ksu.edu

Part I

Accomplishments

1. Advance the science of biological control through fundamental research on the biology of natural enemies and their application in pest management.

a. List the titles, participants, and funding sources of your externally-funded biological control research

1. **Can increased predator foraging efficiency contribute to a more effective and cost-competitive biological program in greenhouse?**

   PIs: David C. Margolies, James R. Nechols, Punya Nachappa (Kansas State University)

   USDA North Central Regional IPM Program

2. **A study of reproductive tradeoffs and lifetime distribution of reproductive effort in three species of lady beetle.**

   PIs: J.P. Michaud, Jim Nechols (Kansas State University)
   Graduate Student: German Vargas

   Fullbright Scholarship Program

b. List citations for your peer-reviewed publications (published this year) on biological control-related research. (Other types of publications will be included below)

Nachappa, Punya, David C. Margolies, James R. Nechols and Theodore J. Morgan. Response of a complex foraging phenotype to artificial selection on its component traits. Evol. Ecol. *In press*. Online link: http://www.springerlink.com/openurl.asp?genre=article&id=doi:10.1007/s10682-009-9318-0

Opit, G.P., J. Perret, K. Holt, J.R. Nechols, D.C. Margolies and K.A. Williams. 2009. Comparing chemical and biological control strategies for twospotted spider mites (Acari: Tetranychidae) in commercial greenhouse production of bedding plants. J. Econ. Entomol. 102: 336-346.

Cheng, Ling Lan, James R. Nechols, David C. Margolies, James F. Campbell, Ping Shih Yang, Chien Chung Chen, and Chiu Tung Lu. 2009. Foraging on and consumption of two species of papaya pest mites, *Tetranychus kanzawai* and *Panonychus citri* (Acari: Tetranychidae) by the green lacewing *Mallada basalis* (Neuroptera: Chrysopidae). Environmental Entomology 38: 715-722.

Rasekh, A., J.P. Michaud, A. Kharazi-Pakdel & H. Allahyari. (2009) Ant mimicry by an aphid parasitoid, *Lysiphlebus fabarum* (Hymenoptera: Aphidiidae). J. Ins. Sci. (in press).

Michaud, J.P. & G. Vargas (2009) Toxicity of three herbicides to two species of Coccinellidae. Ins. Sci. (in press)

Part II

State Project Summaries

1. **Project title:** Effects of genetically-selected lines of the predatory mite, *Phytoseiulus persimilis*, and plant architectural complexity on foraging efficiency and biological control of the twospotted mite.
   Investigators: Ian A. Smith, James R. Nechols David C. Margolies (Kansas State University)

   Summary: Research continues towards our long-term goal of evaluating artificially-selected lines of the predatory mite, *P. persimilis,* for improved foraging efficiency and biological control of the twospotted mite, *Tetranychus urticae*, on greenhouse vegetable and floricultural crops. We have established separate genetic lines for increased levels of four foraging traits: prey consumption, predator dispersal, conversion efficiency (number of predator eggs laid per prey consumed), and response to prey-induced olfactory cues. Currently, we are comparing the high prey consumption and high predator dispersal lines with an unselected colony of *P. persimilis* to determine whether selection improves local (within-prey patch or within plant) and regional (among multiple plants) pest suppression. We are interested in knowing how predators with different levels of these traits distribute offspring and prey consumption within and among prey patches, how this affects pest population dynamics spatially and temporally, and the overall level of prey suppression and pattern of plant damage. Ultimately, we hope to be able to release predators with genetic traits that lead to efficient pest suppression and uniform reduction or prevention of plant damage. Two general hypotheses are: (1) Predators selected for higher consumption will feed more extensively, and leave more offspring, in local (release) prey patches, but will not disperse as quickly as the high-dispersal line or unselected population; and (2) predators selected for high dispersal will leave local patches sooner with fewer offspring left compared to the other two lines. We predict that differences in foraging patterns will affect local and overall pest population dynamics and, thus, patterns of plant damage.

Early results from an experiment in which a single *P. persimilis* female was released into a prey patch on a 6-leafed cucumber plant in which either one leaf or all leaves contained prey eggs suggest that predators selected for high consumption produced more total progeny (implying more predation) than the line selected for high dispersal or the unselected colony. Statistical analyses, data on total prey consumption, and data concerning spatial distribution of predator eggs and prey consumed on cucumber plants are not yet available.

A future experiment will evaluate predator foraging across a large two-dimensional leaf landscape (simulating a canopy of overlapping leaves) under different levels of prey abundance and spatial distribution.

2. **Project title:** A study of reproductive tradeoffs and lifetime distribution of reproductive effort in three species of lady beetle.
Investigators: J.P. Michaud, Jim Nechols, German Vargas (Kansas State University)

Summary: We are conducting detailed examinations of the lifetime reproductive schedules of three coccinellid species: *Harmonia axyridis*, *Hippodamia convergens* and *Coleomegilla maculata*. We are in the process of demonstrating the following: (1) Female body size affects the tradeoff between egg size and egg number (small females reduce egg size in order to preserve egg number); (2) Egg size changes as a function of female age in a species-specific manner; (3) The distribution of reproductive effort over adult life is species-specific and also changes as a function of female size. In addition, we are examining how epigenetic maternal effects (maternal age, maternal body size, egg size) affect offspring fitness. We expect to identify some interesting species contrasts that can be related to species-specific ecology.

Kentucky

State Representative: Jen White
University of Kentucky
jenawhite@uky.edu

Part I
(complete for your program only)

Accomplishments

1. *Advance the science of biological control through fundamental research on the biology of natural enemies and their application in pest management.*

   a. List the titles, participants, and funding sources of your externally-funded biological control research

      1) **Molecular characterization of the microbial symbiont community of invasive arthropods**

         PI: Jennifer White

         Kentucky Science and Engineering Foundation

      2) **Ecological ramifications of defensive symbiosis in an invasive aphid pest**

         PI: George Heimpel, University of Minnesota
         Co-PIs: Mark Asplen, University of Minnesota, Kerry Oliver, University of Georgia
         Keith Hopper, USDA-ARS, Newark DE, Jennifer White, University of Kentucky

         USDA AFRI

   b. List citations for your peer-reviewed publications (published this year) on biological control-related research. (Other types of publications will be included below)

      White, J.A., S. Kelly, S. Perlman, M. S. Hunter. 2009. Cytoplasmic incompatibility in the parasitic wasp *Encarsia inaron*: disentangling the roles of *Cardinium* and *Wolbachia* symbionts. Heredity 102: 483-489.

3. *Educate stakeholders, students, extension personnel and the general public on the principles and practices of biological control.*

   a. List biological control-related talks, symposia, workshops, etc. you gave or organized for the education of other scientists

- White, J. A. 2009. (Invited) Endosymbionts in host-parasitoid systems: relevance to biological control. Joint annual meeting of W2185 and S1034 regional biological control meetings.
- White, J. A., S. Kelly, S. J. Perlman, and M. S. Hunter. 2009. (Invited) Interactions between bacterial endosymbionts within a shared parasitoid host. 1st International Entomophagous Insects Conference.
- White, J. A., S. Kelly, S. J. Perlman, and M. S. Hunter. 2008. Costs and benefits of endosymbiont infection in a doubly-infected parasitoid. Entomological Society of America.

b. List publications or other educational opportunities on biological control you provided for producers, extension educators, and other stakeholders (e.g., extension publications or talks, biological control workshops or training sessions, etc.)

- White, J. A. Greenhouse Pests. Greenhouse 101 Workshop, ~25 Extension Agents.
- White, J.A. and R. Bessin. Alien Invaders. Elizabethtown Garden Club, ~50 gardeners.

c. List number of graduate students, postdocs, and undergraduate researchers you trained in the science of biological control.

- 2 graduate students

Part II

State Project Summaries

1. Project title: Molecular characterization of the microbial symbiont community of invasive arthropods
Investigator: Jen White, University of Kentucky.

Summary: In this project we are investigating the distribution of inherited bacterial symbionts in introduced species (both pests and biological control agents). Symbionts influence many aspects of arthropod life history and ecology (reproduction, dispersal, defense) that are undoubtedly important for the establishment and spread of introduced species. Within the scant literature on symbionts of introduced species, an interesting trend emerges: introduced species tend to have fewer facultative endosymbiont taxa in their exotic than native ranges. We are attempting to validate this pattern by comparing the bacterial symbiont communities of 10 introduced species in their exotic versus native ranges using denaturing gradient gel electrophoresis (DGGE). At a minimum, this preliminary study will identify agriculturally-relevant arthropod species that bear symbionts; these species can subsequently be used to investigate the multitrophic ecological consequences of symbiont

infection. More generally, broad patterns of symbiont loss or retention among introduced species would suggest that symbionts routinely influence and/or are influenced by the process of introduction. Thus, symbionts may represent a new avenue for exploring the causes and consequences of invasiveness. Many important agricultural pests and their biological control agents are exotic in origin; a greater understanding of symbionts in introduced species therefore may ultimately improve biological control, either through selection of target species that are most vulnerable to introduced natural enemies, or through selection of biological control agents with the greatest chance for success.

2. **Project title:** Ecological ramifications of defensive symbiosis in an invasive aphid pest
Investigators: George Heimpel, Mark Asplen (University of Minnesota), Kerry Oliver (University of Georgia), Keith Hopper (USDA-ARS, Newark, DE), Jennifer White (University of Kentucky).

Summary: The heritable bacterial symbiont, *Hamiltonella defensa,* protects the pea aphid, *Acyrthosiphon pisum*, from attack by parasitoid wasps. Despite clear benefits to infection, *H. defensa* remains at intermediate frequencies in natural populations. The spread of *H. defensa* may be limited by costs to infection in the absence of parasitism pressure or by inefficient vertical transmission in the field. Preliminary data suggest that *H. defensa* also defends *Aphis craccivora* against parasitoids, but that it may not protect equally well across parasitoid taxa. Furthermore, while vertical transmission of *H. defensa* is highly efficient in *A. pisum*, we have observed the loss of *H. defensa* in lab-reared *A. craccivora*. Factors promoting variability in aphid defense likely impact both the (1) efficacy and safety of aphid biological control programs and, (2) likelihood of range expansion by symbiont-defended aphid pests. To address these issues, we propose studies of *H. defensa* in *A. craccivora* to demonstrate symbiont-based defense in a second, economically important, aphid-parasitoid system and investigate factors governing *H. defensa* transmission. Specific objectives include: (1) screening *A. craccivora* populations and testing for correlations between *H. defensa*, parasitism, and geographic region, (2) experimentally examining factors that influence symbiont spread, including fitness costs and transmission efficiencies, and (3) comparing parasitism rates of three major aphid parasitoid lineages against *H. defensa*-infected and uninfected *A. craccivora* sharing a common aphid genotype.

3. **Project title:** Defensive chemicals and intraguild predation among predatory ladybeetles
Investigators: Yukie Kajita, John J Obrycki, John J Sloggett, Ken F Haynes, University of Kentucky.

4. **Project Title:** Consumption of sugar by Coccinellids and its effect on colonization of soybean by soybean aphid.
Investigators: Michael Seagraves and Jon Lundgren (USDA-ARS, Brooking, SD), Yukie Kajita and John Obrycki (U of Kentucky), Don Weber (USDA-ARS, Beltsville, MD).

5. **Project Title:** Identity, abundance, and seasonality of black cutworm parasitoids in golf course habitats.
Investigators: Andrea Bixby and Dan Potter, University of Kentucky.

6. **Project Title:** *Agip*MNPV as a bio-insecticide for season-long and multi-year preventive control of black cutworm on golf courses.
   Investigators: Andrea Bixby and Dan Potter, University of Kentucky.

7. **Project Title:** Compatibility of endophytic turfgrasses with biological control of black cutworm by *Agip*MNPV and the parasitoid tachinid fly, *Bonitia comta*.
   Investigators: Andrea Bixby and Dan Potter, University of Kentucky.

8. **Project Title:** Is the tachinid fly, *Bonitia comta*, attracted to kairomones of black cutworm frass??
   Investigators: Andrea Bixby and Dan Potter, University of Kentucky.

9. **Project Title:** Prey utilization by a community of linyphiid spiders: variation across diel and seasonal gradients
   Investigators: Romero, S., Harwood, J.D., University of Kentucky.
   In Press, *Biological Control*

10. **Project Title:** Reduced invertebrate biodiversity affects predator fitness and hence ability to control crop pests
    Investigators: Harwood, J.D., Phillips, S.W., Lello, J., Sunderland, K.D., Glen, D.M., Bruford, M.W., Harper, G.L., Symondson, W.O.C.
    In Press, *Biological Control*

11. **Project Title:** Tracking subterranean density-dependent predation by carabid larvae on slugs using monoclonal antibodies
    Investigators: Thomas, R.S., Harwood, J.D., Glen, D.M., Symondson, W.O.C.
    In Press, *Ecological Entomology*

12. **Project Title:** Aphidophagy by Coccinellidae: application of biological control in agroecosystems.
    Investigators: Obrycki, J.J., Harwood, J.D., Kring, T.J., O'Neil, R.J.
    In Press, *Biological Control*

13. **Project Title:** Quantification of exposure pathways in carabid food webs across multiple transgenic events
    Investigators: Peterson, J.A., Obrycki, J.J., Harwood, J.D., University of Kentucky.
    Published: *Biocontrol Science and Technology*, **19**, 613-625.

14. **Project Title:** Differential impact of adults and nymphs of a generalist predator on an exotic invasive pest demonstrated by molecular gut-content analysis.
    Investigators: Harwood, J.D., Yoo, H.J.S., Greenstone, M.H., Rowley, D.L. & O'Neil, R.J.
    Published: *Biological Invasions*, **11**, 895-903.

15. **Project Title:** Are sweep net sampling and pitfall trapping compatible with molecular analysis of predation?
    Investigator: Harwood, J.D., University of Kentucky.

Published: *Environmental Entomology*, **37**, 990-995.

16. **Project Title:** Molecular and morphological evidence for the occurrence of two new species of invasive slugs in Kentucky, *Arion intermedius*, and *Arion hortensis* (Arionidae: Stylommatophora)
Investigators: Mc Donnell RJ, Paine TD, Stouthamer R, Gormally MJ, Harwood JD
Published: *Journal of the Kentucky Academy of Science*, **69**, 117-123.

17. **Project Title:** Larval feeding on Bt-hybrid and non-Bt corn seedlings by *Harmonia axyridis* (Coleoptera: Coccinellidae) and *Coleomegilla maculata* (Coleoptera: Coccinellidae).
Investigators: Moser, S.E., Harwood, J.D., Obrycki, J.J., University of Kentucky.
Published: *Environmental Entomology*, **37**, 525-533.

Missouri

State Representative: Ben Puttler
University of Missouri
Puttlerbe@missouri.edu

Part II

State Project Summaries

1) **Project Title:** Monitoring soybean aphid..
Investigators: B. Puttler.

Summary: In 2008 soybean aphids migrating back to buckthorn (*Rhamnus cathartica*) was monitored at the University of Missouri campus and Capen Park in Columbia. They first appeared on October 2 and by October 16 high populations of the aphid were observed. Initally the population was being reduced by syrphid larvae. Subsequently, aphid mummies started to appear from which *Lysephlebus testaceipes* emerged as determined by Puttler and confirmed by K. S. Pike. At the same time 100 live aphids were dissected and greater than 90% were parasitized. By November 3 all the aphids were gone and by November 10 all parasites had emerged from the mummies. Throughout the winter and early spring periodic observations to find overwintering eggs on the buds of the buckthorn were negative nor could any live aphids be found later in the spring as the buds leafed out. It appeared that parasites and predators were responsible for eliminating the potential overwintering soybean aphid egg population at the two observation sites.

A completely different situation existed on the two observational sites in Columbia in 2009. The first aphids were detected on September 8 (ca. 1 month earlier than in 2008) and by September 24 buckthorn leaves were covered with alates and small nymphs. No parasites or predators were present. On closer examination, it was observed that the aphids were dying of a fungus in epizootic proportions. Although npo specific identification was obtained it was deduced from slide preparation of dead adults and nymphs that the fungus was typical (as per conidia and resting spores) of one of the enomophthorean species usually associated with aphids. By mid-October very few living aphids were present, thereby confirming the epizootic.

The epizootic is apparently brought about as follows. Alates become infected from fungal spores in the atmosphere as they disperse/swarm from soybeans to locate buckthorn. After arriving on the buckthorn, the disease manifests itself and kills the aphid, although some nymphs may have been laid prior to dying. The nymphs subsequently become infected as the infected alates sporulate. As of mid-Octob er no aphid eggs could be found.

For the first ime the aphid was found on *Rhamnus frangula* and its infestation was being killed by the same fungus as on *R. cathartica.*

The soybean aphid on soybeans in 2009 deviated from that found in 2008. Rather than first being detected in mid-July, this year it was not found until early August in the northwest and

mid-August in central Missouri. By the end of August aphids could be found in practically every soybean in central Missouri and probably in every field throughout the state. There was a conspicuous absence of predators. Yet only an occasional field was reported to be above threshold and these were treated as was some others that did not reach threshold (with W. Bailey, baileyw@missouri.edu).

2) **Project Title:** St. John's Wort (*Hypericum* sp.) Aphid (*Aphis hyperici*) Anthonomus weevil (*A. ungularis*).
Investigators: B. Puttler.

Summary: Over the past four years the phenology of the Aphelinid parasite *Aphelinus* sp. of *Aphis hyperici* has had a slightly year-to-year deviation primarily due to climatic conditions (temperature). Basically the parasite can become active as early as April and maintain itself through November. Adults have been reared in each of the months. The last month's mummies' produced adults, indicated no apparent diapauses; therefore, it is assumed that the parasite overwinters as an adult. Although the possibility exists that since the aphid is capable of overwintering, the parasite could overwinter in parasitized aphids. Occasional aphids collected throughout the winter and dissected contained parasite larvae. Emerging parasite adults had a 3:1 ratio of females to males and the females were proovigenic.

Binodoxys carolinensis, the Aphiidae parasite of the aphid which was present in small numbers in past years, was common this year (2009). It co-existed with the *Aphelinus* as both species' mummies were present on aphid-infested leaves. Adults emerged from all mummies collected and were the apparent overwintering stage as no diapause was indicated.

Syrphophagus aphidivorus was the common hyperparasite on both species of parasites.

In 2009 parasitism of *Anthonomus ungularis* by the Pteromalid *Lyrcus nigroaeneus* from dissections of 100 seed capsules selected at random from *Hypericum kalmianum* varied between sampling dates and sites. For example, at one site sampled 8 times, parasites were found 5 times, with parasitization ranging from 13-39%. It ranged from 1-36% at other sites sampled 1 to 3 times. Weevil infested *H. prolificum* were not parasitized this year by were present in 2008.

3) **Project Title:** Milky disease (*Paenibacillus lentimorbus*)
Investigator: B. Puttler.

Summary: From September through November 2008, no masked chafer or *Phyllophaga* grubs were observed on the zoysia turfgrass surface of the regular sampled 11th fairway where milky disease grubs were present in prior years. Eight infected grubs (*Phyllophaga* sp) were collected during the same time period from other fairways. Thus, making the ninth consecutive year of the disease's presence on the golf course. The maximum number was 241 in 2004. As in 2007 the decline in grubs collected is primarily due to cooler that normal temperatures and reduced rainfall.

As of mid-October 2009, three infected (2 chafers 1 Phyllophaga) were collected from the 11th fairway, 8 from other fairways or t- boxes (all Phyllophaga) and 2 green June beetles. It is anticipated that observations over the next 5 weeks will result in additional diseased grub collections and above normal rainfall has occurred even though temperature has been below normal. The former appears to be the major factor that brings diseased grubs to the turfgrass surface.

4) **Project Title:** Monitoring Spotted knapweed
Investigators: B. Puttler

Summary: In an attempt to hasten establishment and reduction of populations of the noxious spotted knapweed, ca. 17,600 seed weevils (*Larinus* sp) and 8,300 root weevils (*Cyphoclenus achates*) were released at 70 differen sites throughout the weed infestation in the southwest and south central parts of the state.

From releases made in 2008, recoveries of the root weevil were obtained at two sites indicating that establishment might be forthcoming (with Missouri Department of Transportation, Rand Swanigan, University of Missouri Extension).

Nebraska

State Representative: Robert Wright
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Part I

Accomplishments

1. Advance the science of biological control through fundamental research on the biology of natural enemies and their application in pest management.

b. List citations for your peer-reviewed publications (published this year) on biological control-related research. (Other types of publications will be included below)

Carstens, J., T. Heng-Moss, F. Baxendale & R. Wright. 2008. Predation of the chinch bug, *Blissus occiduus* Barber by *Geocoris uliginosus*. J. Kansas Entomol. Soc. 81:328-338.

3. Educate stakeholders, students, extension personnel and the general public on the principles and practices of biological control.

b. List publications or other educational opportunities on biological control you provided for producers, extension educators, and other stakeholders (e.g., extension publications or talks, biological control workshops or training sessions, etc.)

- Wright, R. J., T. A. Devries & J. Kalisch. 2009. Beneficial Insects I, Extension Circular 09-1578, University of Nebraska Extension. Available online at http://www.ianrpubs.unl.edu/sendIt/ec1578.pdf
- Wright, R. J., T. A. Devries & J. Kalisch. 2009. Beneficial Insects II, Extension Circular 09-1579, University of Nebraska Extension. Available online at http://www.ianrpubs.unl.edu/sendIt/ec1579.pdf

Part II

State Project Summaries

5) **Project Title:** Predation of the chinch bug, *Blissus occiduus* Barber by *Geocoris uliginosus*.
Investigators: Carstens, J., T. Heng-Moss, F. Baxendale & R. Wright
Published: 2008. Journal of the Kansas Entomological Society 81:328-338.

Summary: Big-eyed bugs have been well documented as predators on a diverse group of arthropod prey in turfgrasses; however, little is known about the big-eyed bug species associated with buffalograss, or their feeding habits relative to the western chinch bug, *Blissus occiduus* Barber. This research documented that *Geocoris uliginosus* (Say) was the predominant big-eyed bug species associated with buffalograss, obtained information on its feeding behavior, and characterized predation rates. Laboratory studies documented *G. uliginosus*, as a predator of *B. occiduus*. While all life stages of *B. occiduus* were attacked by *G. uliginosus*, predation was greater on 1st through 4th instars than on 5th instars or adults. Low 5th instar and adult chinch bug mortality was likely the result of their larger biomass, as well as their superior size and strength compared to younger (1st through 4th instar) chinch bugs. The mean number of 1st through 3rd instar chinch bugs consumed by *G. uliginosus* at each evaluation period was higher than for 5th instar or adult chinch bugs. Based on this research, chinch bug management decisions should take into consideration big-eyed bug densities, especially when the majority of *B. occiduus* are early (1st–2nd) instars.

North Dakota

State Representative: Deirdre A. Prischmann-Voldseth
North Dakota State University
Deirdre.Prischmann@ndsu.edu

Part I

Accomplishments

1. *Advance the science of biological control through fundamental research on the biology of natural enemies and their application in pest management.*

   a. List the titles, participants, and funding sources of your externally-funded biological control research

      1) **Predation of immature corn rootworms by subterranean mites**

         PI: Deirdre A. Prischmann-Voldseth (North Dakota State University)
         Co-PI: Jonathan G. Lundgren, USDA-ARS, NCARL, Brookings SD

         USDA-CSREES, North Central Integrated Pest Management Center, mini-grant program.

      2) **Integrated pest management of Canada thistles**

         PI: Deirdre A. Prischmann-Voldseth (North Dakota State University)
         Co-PI: Greta Gramig (North Dakota State University)
         Collaborators: R. Lym, M. Harris (North Dakota State University)

         North Dakota Department of Agriculture

      3) **Integrating plant resistance and natural enemies for soybean aphid control**

         PI: Deirdre A. Prischmann-Voldseth (North Dakota State University)
         Collaborators: J. Knodel (North Dakota State University)

         North Dakota Soybean Council grant

      4) **Soybean aphid: management, biocontrol, and host plant resistance**

         PI: David Ragsdale (University of Minnesota)
         Co-PIs / Collaborators: George Heimpel (University of Minnesota), C. DiFonzo, D.

Wang (Michigan), S. Yaninek, M. Rhainds (Indiana), S. Cianzio, M. O'Neal (Iowa), B. Diers, K. Steffey, D. Voegtlin (Illinois), B. McCornack, J. Reese, B. Schapaugh (Kansas), T. Hunt, T. Heng-Moss (Nebraska), K. Tilmon (South Dakota) E.Cullen, D. Hogg (Wisconsin), A. Michel, R. Mian (Ohio) D. Prischmann-Voldseth, J. Knodel (North Dakota State University), K. Hoelmer, K. Hopper (USDA-ARS, Beneficial Insect Introduction Research Unit, Newark DE).

North Central Soybean Research Program

b. List citations for your peer-reviewed publications (published this year) on biological control-related research. (Other types of publications will be included below)

Lundgren JG, Nichols S, **Prischmann DA**, Ellsbury ME. 2009. Seasonal and diel activity patterns of generalist predators associated with *Diabrotica virgifera virgifera* immatures (Coleoptera: Chrysomelidae). Biocontrol Sci. Techn. 19(3): 327-333.

2. *Facilitate the implementation of biological control in production and natural systems.*

a. Please list your accomplishments that helped facilitate the *implementation* of biological control

- I obtained an APHIS permit for releasing the soybean aphid parasitoid *Binodoxys communis* in North Dakota and released it on a cooperating grower's field across the river in MN (in conjunction with G. Heimpel, University of MN).

3. *Educate stakeholders, students, extension personnel and the general public on the principles and practices of biological control.*

b. List publications or other educational opportunities on biological control you provided for producers, extension educators, and other stakeholders (e.g., extension publications or talks, biological control workshops or training sessions, etc.)

- **Prischmann-Voldseth DA**. 2009. Biological control of Canada thistle. North Dakota State University Crop & Pest Report, August 27, 2009. NDSU Extension Service. 14: 3.

c. List number of graduate students, postdocs, and undergraduate researchers you trained in the science of biological control

- 2 current graduate students
- 3 current undergraduate students

Part II

State Project Summaries

1. **Project Title:** Predation of immature corn rootworms by subterranean mites
   Investigators: Deirdre A. Prischmann-Voldseth, Entomology Dept., North Dakota State University, Fargo ND; Jonathan G. Lundgren USDA-ARS, North Central Agricultural Research Lab, Brookings SD

2. **Project Title:** Integrated pest management of Canada thistles
   Investigators: Deirdre A. Prischmann-Voldseth (Entomology Dept., North Dakota State University, Fargo ND) and Greta Gramig, Plant Science Dept., North Dakota State University, Fargo ND

3. **Project Title:** Integrating plant resistance and natural enemies for soybean aphid control
   Investigators: Deirdre A. Prischmann-Voldseth and Janet J. Knodel, Entomology Dept., North Dakota State University, Fargo ND

4. **Project Title:** Integrating biological control and soybean aphid resistant cultivars
   Investigators: Janet Knodel, Kiran Ghising, Patrick Beauzay, and Deirdre Prischmann-Voldseth, Entomology Dept., North Dakota State University, Fargo ND

   Summary: The research goal is to integrate the use of beneficial insects and aphid-resistance breeding to mitigate damage by soybean aphid, *Aphis glycines* Matsumura (Hemiptera: Aphididae) to North Dakota soybean production. In this project, we examine the compatibility of soybean cultivars containing the *Rag1* gene for resistance to soybean aphid with a biological control agent, the parasitic wasp *Binodoxys communis* (Gahan) (Hymenoptera: Braconidae). The specific objective of this study is to determine if *B. communis* fitness is affected when host aphids feed on plants with the *Rag*1 resistance gene. Early results indicate that there were no negative effects to *B. communis* from parasitizing soybean aphids that are developing on *Rag1* plants. Use of biological control agents and aphid-resistant soybean varieties are two strategies that can keep soybean aphid levels below the economic threshold where chemical control is necessary.

Ohio

State Representative: Luis A. Cañas
The Ohio State University / OARDC
canas.4@osu.edu

Part I

Accomplishments

1. Advance the science of biological control through fundamental research on the biology of natural enemies and their application in pest management.

a. List the titles, participants, and funding sources of your externally-funded biological control research

1) **Whitefly preference for poinsettia cultivars: impact of plant host traits on whitefly development, survival and fecundity.**

PI: L. A. Cañas, The Ohio State University / OARDC

American Flower Endowment

2) **Ohio State University Insect Pest Diagnostics short course.**

PI: S. Miller, L. A. Cañas, The Ohio State University / OARDC

USDA-FAS

3) **Biopesticide rotations for management of thrips and whiteflies on greenhouse vegetables.**

PI: L. A. Cañas, The Ohio State University / OARDC

USDA-IR4

b. List citations for your peer-reviewed publications (published this year) on biological control-related research. (Other types of publications will be included below)

Naranjo, S. E., P. C. Ellsworth, and L. Canas. 2008. Mortality and population dynamics of *Bemisia tabaci* within a multi-crop system. Journal of Insect Science 8: 37-37.

Shenge, K. C., P. M. Diedhiou, M. J. Boehm, S. D. Ellis, A. Stone, S. A. Miller, and L. A. Cañas. 2009. Sanitation and Phytosanitation (SPS): The Importance of SPS in

Global Movement of Plant Materials, Ohioline. The Ohio State University Extension, Columbus, OH.

2. *Facilitate the implementation of biological control in production and natural systems.*

   a. Please list your accomplishments that helped facilitate the *implementation* of biological control

   - I developed a collaborative project with a greenhouse tomato grower to implement the use of natural enemies for control of pests in her greenhouse. This project will be used to exemplify the different elements that need to be considered when implementing a biological control program.

   - I coordinated the development of a "bilingual" (English-Spanish) workshop that introduced IPM concepts to pest management operators. Biological control was an important element in this workshop.

   - I developed a collaborative project with Smithers-Oasis (Ohio) to improve the delivery of entomopathogenic nematodes through plant growing media.

   - I served as co PI in the development of an international short course to identify pests important for food security.

   - I developed a project about the use of biopesticides, including fungi and bacteria that can be used to manage insects in greenhouse vegetables.

3. *Educate stakeholders, students, extension personnel and the general public on the principles and practices of biological control.*

   c. List publications or other educational opportunities on biological control you provided for producers, extension educators, and other stakeholders (e.g., extension publications or talks, biological control workshops or training sessions, etc.)

   Talks and workshops

   - Cañas, L.A. "Current advances in insect management in greenhouses." Dayton, OH. 1/21/2009.

   - Cañas, L.A. "Current advances in insect management in interioscapes." Dayton, OH. 1/21/2009.

   - Cañas, L.A. "Insect IPM." Columbus, OH. 1/25/2009.

- Cañas, L.A. "New Discoveries and Trends for Insect Management in Greenhouses and Conservatories." Cincinnati, OH. 2/4/2009.

- Cañas, L.A. "Current advances in insect management in greenhouses." Sandusky, OH. 2/10/2009.

- Cañas, L.A. "Current advances in insect management in interioscapes." Sandusky, OH. 2/10/2009.

- Cañas, L.A. "Current insect management practices in greenhouses." Toledo, OH. 2/17/2009.

- Cañas, L.A. "Current advances in insect management in greenhouses." Columbus, OH. 2/25/2009.

- Cañas, L.A. "Current advances in insect management in interioscapes." Columbus, OH. 2/25/2009.

- Cañas, L.A. "Current advances in insect management in greenhouses." Akron, OH. 3/11/2009.

- Cañas, L.A. "Current advances in insect management in interioscapes." Akron, OH. 3/11/2009.

- Cañas, L.A. Biological control at Zoos and Conservatories: a potential educational experience! NCERA 125 Symposium: ESA-NCB Annual Meeting. St. Louis, MO. 3/14/2009.

- Cañas, L.A. "Using Ecological Approaches to Answer Questions about Insect Pest Management in Controlled Environments." Horticultural and Crop Sciences Department, OSU/OARDC. Wooster, OH. May 15, 2009.

- Cañas, L.A. Insect Science Workshop. Credits: 5, Enrollment: 14. Guest Lecture: "Greenhouse Insects" Mount Union College. 75% of the students in class were able to recognize the major greenhouse insect pests by the end of the lecture and learned about biological controls (only 8% were able to do so at the beginning of the lecture). 5/18/2009

- Cañas, L.A. Extension Reloaded: insect management using IPM. Cincinnati Flower Growers Association – Coordinated by Dave Dyke. Approximate number of participants = 52 people. Presented information about problems observed during the onsite visit and discussed options for control. Oral presentation, Cincinnati, OH. 6/3/2009.

- Cañas, L.A. Extension Reloaded: insect management using IPM. OFA Short Course – Coordinated by Claudio Pasian and Steve Carver. Approximate number of

participants = 81 people. Presented information about problems observed during the onsite visit and discussed options for control. Oral presentation, Columbus, OH. 7/15/2009.

Publications

- Shenge, K. C., P. M. Diedhiou, M. J. Boehm, S. D. Ellis, A. Stone, S. A. Miller, and L. A. Cañas. 2009. Sanitation and Phytosanitation (SPS): The Importance of SPS in Global Movement of Plant Materials, Ohioline. The Ohio State University Extension, Columbus, OH.

c. List number of graduate students, postdocs, and undergraduate researchers you trained in the science of biological control

- 2009. Ronald Batallas. Ecuador. Panamerican College of Agriculture, Honduras. February 14 – December 14, 2009. Undergraduate student intern.

- 2009. Theodore Derksen, SU Quarter 2009, senior high school student. Awards: Awarded OARDC Research Internship Program scholarship. June 9 to September 12, 2009. Undergraduate student intern.

- 2009. Gabriel Abud, SU Quarter 2009, senior high school student. Awards: Awarded OARDC Research Internship Program scholarship. June 9 to September 12, 2009. Undergraduate student intern.

- 2009. The Ohio State University. ENT 460. Economic Entomology and Insect Pest Management. Credits: 5, Enrollment: 23. Supported the class lead by Celeste Welty and Dave Shetlar. Winter Quarter, 6 January 2009 to March 14, 2009. Discussed principles of pest management and explained major tactics. The class was transformed to a computer assisted course as a stepping stone into converting it to a distance education class.

Impacts

The goal of NCERA-125 is to coordinate biological control research, education, and implementation in the North Central Region. Our stakeholders – the benefactors of our collaborative work on biological control – include farmers, land managers, homeowners, green industries, regulatory agencies, commodity groups, and the broader scientific community.

Where impact data are available for your accomplishments listed above, please list them below. Impact statements should show the concrete evidence of results or benefits of a given project.

- I organized the shortcourse “Best management practices to Successfully Manage Insects in Greenhouses.” This 1 hour course was delivered at 4 sites in Ohio, to 163 stakeholders.

- I participated in the program "Insect Science Workshop." Mount Union College. 75% of the students in class were able to recognize the major greenhouse insect pests by the end of the lecture and learned about biological controls (only 8% were able to do so at the beginning of the lecture).

- I organized the program "Using chemicals compatible with beneficials in conservatories and small production greenhouses" From the participants 77% of stockholders were able to identify which chemicals were compatible with biological control agents.

Part II

State Project Summaries

1. **Project Title:** Increasing the services of soil invertebrates in agroecosystems.
   Investigators: Hoy, C.W., and Grewal, P.S., Ohio State Univ., Dept. of Entomology, Wooster, OH.

   Summary: New project, CSREES / 2009-35900-05934, addresses how the spatial distribution of beneficial soil invertebrates could be managed to increase the ecosystem services they offer. Our previous research indicates that survival, reproduction and dispersal of entomopathogenic nematodes (EPNs), naturally occurring biological controls for soil insect pests, interact to determine their spatial distribution. Therefore, three objectives will be explored in this research: 1.) Enhancing EPN survival with a soil management system that maintains soil fertility while promoting survival of EPNs. The conventional and alternative soil management systems will be established in small plots and survival and establishment of EPNs will be measured over time along with soil food web structure and soil nutrient pools. 2.) Enhancing non-pest alternative host populations to sustain EPN reproduction. Cover crop and compost mixtures will be established to build diverse soil-dwelling insect communities as alternative, non-pest hosts for EPNs. 3.) Examining landscape flows of non-pest insects that could be phoretic hosts of EPNs, and relating numbers of dispersing insects to EPN distribution. Survival, reproduction and dispersal will be examined individually and in combination to determine how they interact to influence EPN spatial patterns and how they change the soil food web over time.

2. **Project Title:** Use of Molecular Community Profiling and Marker Assisted Selection to Identify Novel Biocontrol Strains.
   Investigators: Brian McSpadden Gardener, Dept. of Plant Pathology, Ohio State University.

   Summary: We have used TRFLP and multivariate statistics to identify markers for functionally important soilborne and plant-associated microbial populations, specifically those associated with soilborne disease control.

Publication: Benitez, M.-S., and McSpadden Gardener, B. 2009. Linking sequence to function in soil bacteria: Sequence-directed isolation of novel bacteria contributing to soilborne plant disease suppression. Appl. Environ. Microbiol. 75:915-924. PDF

3. **Project Title:** Evaluation of DAPG-Producing Pseudomonas spp. for biocontrol of soilborne diseases.
   Investigators: Brian McSpadden Gardener, Dept. of Plant Pathology, Ohio State University.

   Summary: Bacterial seed treatment with phlD+ bacteria can significantly increase stand and or yields of various crops. We have recently shown that such treatments can also suppress abiotic nutrient stress disorders associated with growth in very acidic soils.
   Publications: Raudales, R.E., Stone, E., and McSpadden Gardener, B. 2009. DAPG-producing pseudomonads improve crop health in acidic soils by altering patterns of nutrient uptake. Phytopathology. 99:506-511.
   McSpadden Gardener, B. B. 2009. Distribution, Modes of Action, and Practical Applications of DAPG-producing Pseudomonas spp. Pages 32-40 in Proceedings of the 2009 International Symsposium on Green Technology in Agriculture, Chonnam National University, Gwanju, South Korea.

4. **Project Title:** Evaluating predation of native lady beetle eggs at the landscape scale.
   Investigators: Mary Gardiner, Dept. of Entomology, The Ohio State University, Wooster, OH.

5. **Project Title:** Measuring biocontrol and pollination services within urban community gardens.
   Investigators: Mary Gardiner, Scott Prajzner, Parwinder Grewal, Dept. of Entomology, The Ohio State University, Wooster, OH.

6. **Project Title:** Measuring the economic and ecological costs and benefits of floral resource strips within vegetable production systems.
   Investigators: Mary Gardiner, Dept. of Entomology, The Ohio State University, Wooster, OH.

7. **Title:** Common buckthorn as a keystone invader in the agricultural landscape.
   Investigators: Mary Gardiner and Andy Michel, Dept. of Entomology, The Ohio State University, Wooster, OH, Matt O'Neal, Dept. of Entomology, Iowa State University, and Doug Landis, Dept. of Entomology, Michigan State University.

8. **Project Title:** Parasitism of cabbageworms.
   Investigators: Celeste Welty, Dept. of Entomology, The Ohio State University, Columbus, OH.

   Summary: Note on parasitoids on cabbageworms: In an insecticide trial on cabbage in Ohio in 2009, parasitism of all four common cabbageworm species was found but a new species of parasitoid was present. Our most common parasitoid of imported cabbageworm in recent years has been Cotesia glomerata, which is found as clumps of yellow cocoons. The species

found this year is likely Cotesia rubecula, which has single white cocoons. C. rubecula has been recently reported from Massachusetts to be displacing C. glomerata (van Driesche 2008, Fl. Ent. 91(1):22-25). Specimens were collected in Ohio and will be sent for species confirmation this winter. Would be interesting to know if anyone is tracking this species in the Midwest.

9. **Project Title:** Impact of irrigation and nutrient variation on the population dynamics of fungus gnats and some entomopathogenic nematodes used for their control.
   Investigators: Luis A. Cañas, Gampati B. Jagdale, Parwinder Grewal. Dept. of Entomology, The Ohio State University, Wooster, OH.

10. **Project Title:** Development of a novel nematode release system for preventive management of the fungus gnat *Bradysia difformis* in ornamentals.
    Investigators: L. Cañas, Dept. of Entomology, The Ohio State University, Columbus, OH.

11. **Project Title:** Mechanisms of resistance of *Euphorbia pulcherrima* (Euphorbiaceae) to *Bemisia tabaci* biotype B (Hemiptera: Aleyrodidae) and their effects on tri-trophic interactions.
    Investigators: Karla Medina-Ortega and Luis A. Cañas. Dept. of Entomology, The Ohio State University, Wooster, OH.

12. **Project Title:** Using biological control to manage aphids (Homoptera: Aphididae) on hydroponic lettuce.
    Investigators: L. Cañas, Dept. of Entomology, The Ohio State University, Columbus, OH.

North Central Agricultural Research Laboratory, Brookings, SD

Representative: Jonathan G. Lundgren
USDA-ARS
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Part I

Accomplishments

1. Advance the science of biological control through fundamental research on the biology of natural enemies and their application in pest management.

b. List citations for your peer-reviewed publications (published this year) on biological control-related research. (Other types of publications will be included below)

Duan, J. J., **J. G. Lundgren**, S. E. Naranjo, and M. Marvier. 2009. Extrapolating non-target risk of Bt-crops from laboratory to field. Biology Letters.

Lehman, R. M., **J. G. Lundgren,** and L. Petzke. 2009. Bacterial communities associated with the digestive tract of the predatory ground beetle, *Poecilus chalcites*, and their response to laboratory rearing and antibiotic treatment. Microbial Ecology 57: 349-358.

Lundgren, J. G. 2009. Nutritional aspects of non-prey foods in the life histories of predaceous Coccinellidae. Biological Control 51(2) 294-305. (*Invited Review*).

Lundgren, J. G., M. E. Ellsbury, and D. A. Prischmann. 2009. Analysis of the predator community of a subterranean herbivorous insect based on polymerase chain reaction. Ecological Applications, 19(8): 2107-2116.

Lundgren, J. G., A. Gassmann, J. Bernal, J. J. Duan, J. Ruberson. 2009. Ecological compatibility of GM crops and biological control. Crop Protection 28(12): 1017-1030.

Lundgren, J. G., T. Haye, S. Toepfer, and U. Kuhlmann. 2009. A multifaceted hemolymph defense against predation in *Diabrotica virgifera* larvae. Biocontrol Science and Technology 19(8): 871-880.

Lundgren, J. G., L. S. Hesler, K. M. Tilmon, K. E. Dashiell, R. Scott. 2009. Direct effects of soybean varietal selection and *Aphis glycines*-resistant soybeans on natural enemies. Arthropod-Plant Interactions 3: 9-16.

Lundgren, J. G., S. Nichols, D. A. Prischmann, M. E. Ellsbury. 2009. Seasonal and diel activity patterns of generalist predators associated with *Diabrotica virgifera* immatures (Coleoptera: Chrysomelidae). BioControl Science and Technology 19(3): 327-333.

Lundgren, J. G., K. Wyckhuys, and N. Desneux. 2009. Population responses by *Orius insidiosus* to vegetational diversity. BioControl 54(1): 135-142.

Toepfer, S., T. Haye, M. Erlandson, M. Goettel, **J. G. Lundgren,** R.G. Kleespies, D. C. Weber, G. Cabrera Walsh, J. Jackson, A. Peters, R.-U. Ehlers, H. Strasser, D. Moore, S. Keller, S. Vidal, U. Kuhlmann. 2009. A review of the natural enemies of beetles in

the subtribe Diabroticina (Coleoptera: Chrysomelidae): Implications for sustainable pest management. Biocontrol Science and Technology 19(1): 1-65.

Weber, D. C., and **J. G. Lundgren**. 2009. Trophic ecology of the Coccinellidae: assessments of their roles as predators and as prey. Biological Control 51(2): 199-214 (*Invited review*).

Weber, D. C., **and J. G. Lundgren**. 2009. Quantification of predation using qPCR: Effect of prey quantity, elapsed time, chaser diet, and sample preservation. Journal of Insect Science 9: 41.

3. *Educate stakeholders, students, extension personnel and the general public on the principles and practices of biological control.*

a. List biological control-related talks, symposia, workshops, etc. you gave or organized for the education of other scientists

- Presented 10 invited talks, organized one symposium, organized one short course on the topic of biological control.

b. List publications or other educational opportunities on biological control you provided for producers, extension educators, and other stakeholders (e.g., extension publications or talks, biological control workshops or training sessions, etc.)

- Wrote the book "Relationships of Natural Enemies and Non-prey Foods, Springer, 460 pages."
- Co-edited (w/ Don Weber) the Special Journal issue titled "Trophic Ecology of the Coccinellidae" for Biological Control.
- Organized the short course Basic and Applied Ecology of the Coccinellidae, Amboy, IL, July 5-9, 2009. 10 students attended.

c. List number of graduate students, postdocs, and undergraduate researchers you trained in the science of biological control

- Supervised one post-doc.

d. List biological control-related publications and other communications to the public (e.g., radio interviews, newspaper articles, etc. Summarize as appropriate, such as "three radio interviews")

- Write the 500-word monthly newspaper column "Insect Spotlight" (up to 300,000 circulation) which often focuses on natural enemies.
- Regularly interviewed by magazines and newspapers on biologically-based pest management.
- Regularly presented information on the importance of generalist predators to three farm groups at field days and extension events

Part II
(complete for your program and any other program on which you wish to report)

State Project Summaries

1) **Project title:** Generalist predators as a pest management solution for corn rootworms.
   Investigators: Lundgren, J.G. (USDA-ARS), Prischmann, D. (NDSU), Fausti, S. (SDSU), Beck, D (SDSU).

2) **Project title:** The physiology of predator digestion of prey-associated protein markers.
   Investigators: Lundgren, J. G. (USDA-ARS), Harwood, J.D. (UKY)

3) **Project title:** The importance of seed predators in the population dynamics of dandelions.
   Investigators: Lundgren, J. G. (USDA-ARS), Saska, P. (Czech Republic), Honek, A. (Czech Republic).

4) **Project title:** Ontogenetic changes in the digestive capabilities of an omnivorous lady beetle (*Coleomegilla maculata*).
5) **Investigators:** Lundgren, J. G. (NCARL, USDA-ARS), Weber, D.C. (IIBBL, USDA-ARS)

6) **Project title:** The influence of plant characteristics on oviposition behavior in an omnivorous bug (*Orius insidiosus*).
   Investigators: Seagraves, M.P., Lundgren, J. G., Riedell, W.E. (USDA-ARS).

7) **Project title:** The consumption of sugar resources by lady beetles in the field.
   Investigators: Seagraves, M.P. (NCARL, USDA-ARS), Kajita, Y. (UKY), Weber, D.C. (IIBBL, USDA-ARS), Obrycki, J.J. (UKY), and Lundgren, J. G. (NCARL, USDA-ARS).

8) **Project title:** Interactions of insecticidal seed treatments with omnivorous predators in soybeans.
   Investigators: Seagraves, M.P., Lundgren, J. G. (USDA-ARS).

9) **Project title:** Finding lost lady beetles in SD
   Investigators: Hesler, L.S. (USDA-ARS), Catangui, M. (SDSU), Losey, J. (Cornell)

South Dakota

State Representative: Kelley Tilmon
South Dakota State University
Kelley. Tilmon@sdstate.edu

Part I

Accomplishments

1. Advance the science of biological control through fundamental research on the biology of natural enemies and their application in pest management.

a. List the titles, participants, and funding sources of your externally-funded biological control research

1) **Ecology and management of soybean aphid and other insect pests of soybean**

PI: Kelley Tilmon, South Dakota State University

South Dakota Soybean Research and Promotion Council

2) **Soybean Aphid: Management, Biocontrol, and Host Plant Resistance**

PI: David Ragsdale, University of Minnesota
Co-PIs: Kelley Tilmon, South Dakota State, and participants in 10 other states

North Central Soybean Research Program

3) **Releasing *Binodoxys communis* for soybean aphid suppression**

PI: Matt O'Neal, Iowa State University
Co-PI: Kelley Tilmon, South Dakota State

Iowa Soybean Association

4) **Biological control of the soybean aphid** (project terminates March 2010)

PI: David Hogg, University of Wisconsin
Co-PIs/Collaborators: University of Illinois (K. Steffey), Illinois Natural History Survey (D. Voegtlin), Iowa State University (M. O'Neal), Michigan State University (C. DiFonzo, D. Landis), University of Minnesota (D. Ragsdale, G. Heimpel), Purdue University (M. Rhainds), South Dakota State University (K. Tilmon), USDA/ARS Beneficial Insect Introductions Research Unit, Newark, DE (K. Hopper, K. Hoelmer), and University of Wisconsin (D. Hogg, C. Gratton, D. Mahr, E. Cullen). Overseas

collaboration with: Japan - University of Utsunomiya, and Japanese National Agricultural Research Service; China - Chinese Academy of Sciences, and USDA/ARS Sino-American Biological Control Laboratory, Beijing; and Korea - Seoul National University.

North Central Soybean Research and Promotion council

b. List citations for your peer-reviewed publications (published this year) on biological control-related research. (Other types of publications will be included below)

Mičijević, A., K. J. Tilmon, R. Barrick, S. Sutera, L. Wagner, C. Strunk, P. Johnson, G. Erickson, and R. Gosmire. 2009. The release of a new beneficial insect for the biological control of soybean aphid, a crop pest in South Dakota. Proceedings of the South Dakota Academy of Science. In press.

2. *Facilitate the implementation of biological control in production and natural systems.*

a. Please list your accomplishments that helped facilitate the *implementation* of biological control

- We conducted followup monitoring at 10 locations where we released the soybean aphid biological control agent, *Binodoxys communis* in 2008. Binodoxys-like mummies were recovered at four locations. We reared adults from these mummies and identifcation is pending.

- We coordinated the release of the soybean aphid biological control agent, *Binodoxys communis*, in 12 additional sites in my state in 2009. We will conduct followup monitoring next season.

3. Educate stakeholders, students, extension personnel and the general public on the principles and practices of biological control.

a. List biological control-related talks, symposia, workshops, etc. you gave or organized for the education of other scientists

- NCERA-125 Program Symposium at the 2009 ESA North Central Branch Meeting: More Biological Control Please: Extension and Outreach Efforts to Increase Awareness and Appreciation of Natural Enemies.
    i. Organizers: Kelley Tilmon and Matt O'Neal
    ii. Approximate attendance: 50
- Symposium talk, NCERA-125 Program Symposium at the 2009 ESA North Central Branch Meeting: Oofta! Selling biological control to Norwegian bachelor farmers in the Upper Midwest. K. Tilmon and M. O'Neal

- Poster, Entomophagous Insect meeting, University of Minnesota

b. List publications or other educational opportunities on biological control you provided for producers, extension educators, and other stakeholders (e.g., extension publications or talks, biological control workshops or training sessions, etc.)

- Spoke about soybean aphid biological control at four field-day tours
- Included soybean aphid biological control in talks at three winter meetings with producers
- Produced slide set on classical biological control of soybean aphid (*B. communis*) for use by South Dakota extension educators

c. List number of graduate students, postdocs, and undergraduate researchers you trained in the science of biological control

- One PhD student, Ana Micijevic

d. List biological control-related publications and other communications to the public (e.g., radio interviews, newspaper articles, etc. Summarize as appropriate, such as "three radio interviews")

- Interview for one newspaper article
- Interview for trade magazine article
- Two radio interviews

Impacts

The goal of NCERA-125 is to coordinate biological control research, education, and implementation in the North Central Region. Our stakeholders – the benefactors of our collaborative work on biological control – include farmers, land managers, homeowners, green industries, regulatory agencies, commodity groups, and the broader scientific community.

Where impact data are available for your accomplishments listed above, please list them below. Impact statements should show the concrete evidence of results or benefits of a given project.

- NCERA-125 Program Symposium at the 2009 ESA North Central Branch Meeting: More Biological Control Please: Extension and Outreach Efforts to Increase Awareness and Appreciation of Natural Enemies.
    i. Organizers: Kelley Tilmon and Matt O'Neal
    ii. Approximate attendance: 50

Part II

State Project Summaries

1. **Project title:** Releasing *Binodoxys communis* for soybean aphid suppression
   Investigators: Matt O'Neal, Kelley Tilmon

2. **Project Title**: Resistant varieties and interactions with soybean aphid biocontrol agents: How do natural enemies affect aphid population doubling time on Rag1 resistant lines
   Investigators: Kelley Tilmon, Deirdre Prischmann, Brian McCornack, Chirs DiFonzo, Christian Krupke, Dave Hogg, Dave Ragsdale.

   Summary: Aphid population growth rate is one of the primary underlying factors in determining economic thresholds, because it dictates how quickly a population can be expected to reach the economic injury level. Cage-exclusion studies in susceptible soybeans have demonstrated that natural enemies are an important factor lowering aphid population growth rate significantly compared to their intrinsic population growth potential. Natural enemies slow aphid population growth, which results in a higher threshold. Natural enemies are likely to serve a similar function in resistant soybeans, but the magnitude of their impact is unknown – and may vary from susceptible soybeans because the aphid intrinsic growth potential is different on resistant plants, which may affect the population dynamics between aphids and natural enemies. This experiment is designed to measure how natural enemies impact aphid population growth rate on resistant lines, thus serves as a companion study to NCSRP project Objective 1a to recalibrate thresholds for resistant lines.