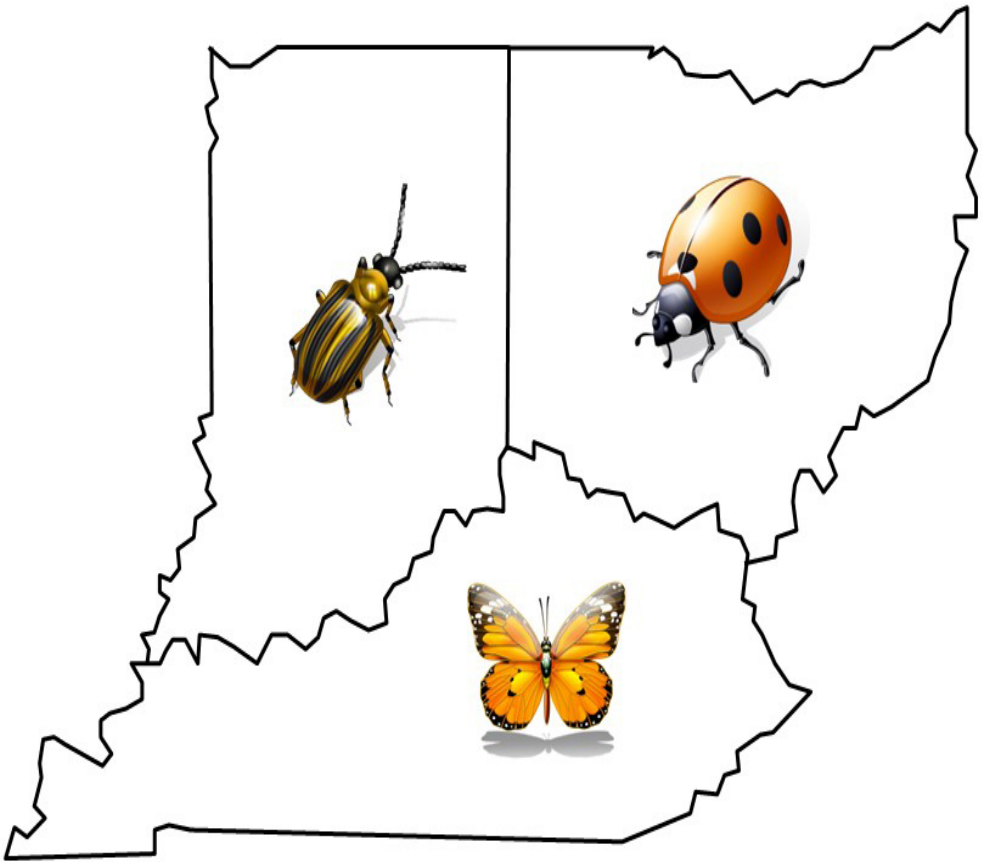
The Ohio Valley Entomological Association
29th Annual Forum

Beck Agricultural Center, Purdue University
West Lafayette, IN 47906

November 4th, 2016



Program Book

Schedule of Events

Activity	Time	
Breakfast and Registration, Upload Talks	9:00-9:55	
Welcome	**9:55**	
Bachelor of Science		**Master of Science**
1 Zain, Ashari	10:10	1 Gula, Scott
2 Lallo, Madeline M.	10:22	2 Klem, Crystal
3 Savage, Benjamin A.	10:34	3 Stack, Sara
4 Pant, Swati	10:46	4 Pickett, Emily
5 Jimenez, Robin Bautista	10:58	5 Stewart, Tyler J.
6 Griebenow, Zachary H.	11:10	6 Riley, Christopher B.
7 Kaur, Jasleen	11:22	7 Price, Garrett Y.
	11:34	8 Quellhorst, Hannah E.
	11:46	9 Blood, Bridget L.
BS/MS Judging	11:58	
LUNCH	12:00-1:00	
Doctor of Philosophy		
1 Olaya-Arenas, Paola	1:00	
2 Hughes, Gabriel P.	1:12	
3 Yates, Ashley	1:24	
4 Yoon, June-Sun	1:36	
5 Penn, Hannah J.	1:48	
6 Vidal-Gomez, Ulianova	2:00	
7 Quesada, Carlos	2:12	
8 Ethington, Matthew	2:24	
PhD Judging & BREAK	2:36-2:55	
Awards	2:55-3:15	
Business Meeting and Conclusion	3:15-3:45	

Preface and Acknowledgements

Welcome to the Ohio Valley Entomological Association's 29th Annual Forum. Thank you for joining Purdue University's Department of Entomology for this year's competition!

The Ohio Valley Entomological Association meeting is a one-day gathering of the students and professional entomologists from the academic, government, and industry sectors. The primary mission of the forum is to cultivate professional development of students, as well as to encourage them to showcase their research. This year, we will continue fulfilling the mission of the forum with 24 student oral presentations representing five different colleges and universities. I hope you will enjoy yourselves!

This event would not have been possible without the support and encouragement of many. First and foremost, I would like to thank the Department of Entomology at Purdue University for being incredibly supportive towards our organization and for this event. I am also grateful to Beck Agricultural Center at Purdue University for providing this year's location and accompanying set-up. I would like to thank Dr. Linda Mason who was abundantly helpful and offered invaluable assistance, support, and guidance. Additionally, I would like to thank Dr. Stephen Cameron for his enthusiastic support of OVEA and Dr. John Sedlacek for financial planning. Many thanks go to the former OVEA presidents Hannah Penn (UK) and the current members of the executive committee for providing insight and information regarding the planning of this meeting. I would also like to take this opportunity to thank all of the faculty, staff, and my colleagues in the Department of Entomology at Purdue University for their insight and help during the various stages of meeting planning. Deepest gratitude is also owed to Tammy L. Luck for her excellent technical support with the overall meeting set-up. Additionally, I would like to express my gratitude and appreciation to our Judges and volunteers for this meeting.

Finally, I extend my sincere gratitude to our sponsors, without whom no awards or food would be possible. Listed below are our sponsors (listed in alphabetical order).

Dow AgroSciences
DuPont Pioneer
Indiana Pest Management
Insects Limited
J. T. Eaton and Co.
The Ohio State University
Purdue University
SpensaTech
Syngenta

Again, thank you all for attending and making this meeting a success!

Sincerely,
Kabita Kharel, President 2016
Ohio Valley Entomological Association

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Sponsors

History and Organization of the Ohio Valley Entomological Association Annual Forum for Student Paper Competition

The Ohio Valley Entomological Association (previously the Ohio Valley Chapter of ARPE) has had a number of successful activities including programs for recertification, exhibits at branch and national Entomological Society of America meetings, occasional newsletters, and a *Forum for Student Paper Presentation*. None of the Chapter activities have been more successful than the Forum, and it became a source of pride with the membership and the envy of other ARPE chapters. Prior to development of the Student Forum, the meetings of the chapter were primarily social gatherings. In November 1984, M.C. Wilson proposed that the Chapter, as an organization, develop a student-related activity.

Students are our future. What better investment could we make with our time and energy than to promote our concepts of professionalism with them? The response was tremendous. Wilson received many letters endorsing the idea, which led to his election as President of the Chapter at the next meeting, and the initiation of a student contest became the Chapter's first project.

Since the program began in 1985 at Earlham College, it has grown steadily. It began in a small way with competition largely between students from the University of Kentucky and Purdue University. This was to be expected because there were significant numbers of faculty from these two institutions who supported and held membership in ARPE. Also, along with Ohio State University, they are the main centers for entomological training in the tri-state area.

With the birth of The Ohio Valley Entomological Association, membership and competition have been opened to all interested parties regardless of demographics or non-affiliation with other organizations. We hope to continue to grow participation beyond the already 300+ contestants who have competed over the years. The constant improvement in the professional quality of the student presentations in recent years is impressive; Ohio Valley entomologists rank these presentations equivalent to the best given at any society meeting.

Objectives of the Contest

The purpose for conducting this competition is multifold:

- To promote an interest in entomology as a career.
- To promote professionalism in our science.
- To recognize student excellence by giving them the opportunity to present a paper before their peers and to have an abstract attesting to this activity in print.
- To foster a dynamic and competitive spirit among young biologists
- To enhance interaction between biology departments in the colleges in the tristate area and give students the opportunity to meet faculty and discuss opportunities for graduate programs in the various universities.
- To give students the opportunity to interact with professional career entomologists from industry, universities and the public sector.

Format for Competition

The Annual Forum for Student Paper Competition is open to any undergraduate or graduate student who has an interest in entomology. To date participants have come from colleges in the tri-state area of Indiana, Kentucky and Ohio; however, students from other states are encouraged to enter the competition. Students who are enrolled in biology courses, or are majoring in biology or entomology departments at the undergraduate level are particularly encouraged to enter the contest.

- Eligibility is based on enrollment for, or recent completion of, a degree.
  A student who has graduated is still eligible if enrolled within the past 12 months. Likewise, a student who recently received a Master of Science degree and is newly enrolled for a doctorate may enter competition at the Master of Science level.
- Papers presented may pertain to the area of entomological science.
- Separate competitions are conducted in each of three categories:
  Undergraduate, Master of Science, and Doctor of Philosophy.
- The paper may present a special problem, MS thesis, Ph.D.
  dissertation, or be on a topic to popularize entomology.
- A classic abstract of no more than 300 words (statement of problem,
  objectives, methods, results and conclusions) for research presentations is required. The abstract for popular science presentations should be a summary, 300 words or less, including: 1) an introductory statement, 2) brief discussion of content, and
  3) conclusions.
- Ten minutes are allotted for presentation followed by two minutes for
  questions. Each presentation is timed.
- Presentations are scored by a panel of five judges representing
  academia, public and private sector.
- Recognition takes the form of certificates and cash awards in each of
  the three for each student categories: $350 first, $250 second, and
  $150 third prize.

Judging Panels

A panel of five judges for each category of competition determines the winners. Each panel is composed of two representatives from either the agricultural or pest control industries and three members from academia, two of whom are usually from biology departments. Professional representatives of both basic and applied science are always included on each panel. Judges may or may not be entomologists. In the event of a tie, the winners will be chosen by a vote of judges.

Emphasis in this student contest is placed on the mechanics of organizing and presenting a scientific paper. The quality of the research is judged only to the extent that the student's objectives and methodology appear appropriate and conclusions are substantiated by data. Judges are expected to write constructive criticism. This is important to the student; score sheets are returned to the students so that they can learn where they need to improve.

A week before the contest each judge receives a copy of the Book of Abstracts to review. Some of the questions that judges should consider are the following. How is the abstract written? Does it have the essentials of a classic abstract? Does it have a statement of the problem, objectives, methodology, results and/or conclusions? Are these conveyed with a reasonable amount of verbiage, using correct English grammar and composition?

In the organization and presentation of the talk, the judges look to see if the student follows through the discussion in a logical manner. Judges expect that the presentations will not specifically target an audience having a general biological background. Finally, it is interesting to note that judges have become more observant of professional appearance and the elements of courtesy.

Coordination of Program

A committee works with industry, which generously supports the contest through prize monies for each of the three categories of competition. In addition, funds from industry provide for continental breakfast at registration, and participating students will be given a lunch voucher. Aside from monetary contributions, personnel from industry have contributed to the success of the contest by serving as judges and working on committees for its promotion.

Mailings announcing the contest and calling for papers are sent to all academic biology departments in the tri-state area, coordinated by staff at Ohio State University, University of Kentucky, and Purdue University. Biology departments serve as hosts, providing local arrangements as the contest moves from state to state. Provision has to be made for the operation of concurrent sessions when necessary. Finally, a committee provides for projection and timing during the presentations, and tabulation of results.

Following the presentation of the last contest paper, results are tabulated and an Awards ceremony is held during which prizes and certificates are distributed to winners as they are presented with their checks.

The Results

The contest has provided a common interest for Ohio Valley entomologists and is opening the door to greater interaction among the three states. Graduate students, particularly in the large entomology departments, have more interaction between universities, fostering a competitive camaraderie. We have been pleased with our graduate level participation.

The graduate level has been relatively stable, and we have tried for years to increase and encourage undergraduate participation. Getting the interest of undergraduates is difficult, requiring the persistence of instructors.

The most significant achievement of the Student Forum is an increased interaction between entomologists representing industry and the faculties and students of academic biology departments in the three states. Here is the source of students for graduate school and industry. This relationship is developing slowly, but we are encouraged with our progress.

OVEA 2015 Annual Forum Winners

Bachelor of Science Category

1st Place: Hannah Quellhorst, Purdue University
2nd place: Madeline Lallo, University of Cincinnati
3rd place: Hannah Stewart, Purdue University

Master of Science Category

1st Place: Katherine Todd, The Ohio State University
2nd Place: MaLisa Spring, The Ohio State University
3rd Place: Alex Styer, University of Kentucky
3rd Place: Alexandra Duffy, Purdue University

Doctor of Philosophy Category

1st Place: Sydney Crawley, University of Kentucky
2nd Place: Brittany Peterson, Purdue University
3rd Place: Alexander Sweger, University of Cincinnati

OVEA Score Sheet

Competitor Name_____ Time: _____

BS MS PhD

Written abstract (10 point total): *Comments* _____

Organization English (5)

Clarity Composition (5)

Organization and Impact (55 points total): *Comments* _____

Introduction, Explanation of problem (10)

Methods & Results (Interpreta-tion of)) (10)

Effective Closing Summary, Conclusions (10)

Originality, Substance, and Impact (15)

Response to questions (10)

Delivery Technique and Skill (20 points total): *Comments* _____

Voice, Grammar, Enunciation (5)

Eye Contact and Enthusiasm (5)

Use of Time *cannot exceed 10 min* (5)

Courtesy and Professionalism (5)

Visual Aids (15 points total): *Comments* _____

Quality and Appropriateness of Visuals (15)

Grand Total Score _____

Bachelor of Science

Food Preferences and Its Application as Fipronil Bait on Subterranean Termites (Isoptera: Termitidae) under Field Conditions

Ashari Zain[1] and Intan Ahmad[2]

[1]Department of Entomology, Purdue University, West Lafayette, IN 47907

[2]School of Life Sciences and Technology, Institut Teknologi Bandung Jln. Ganesha 10 Bandung, Indonesia

Termites are one of the major urban pest that damaging structures and cause economic loss. One of the methods considered effective to control it is using bait system. However, the success rate of the method might vary depend on termite's species, geographical locations, and bait materials. This study evaluated five different materials in an area which *Odontotermes javanicus* colonies present. A triple capture-mark-recapture method was conducted to determine the size of foraging individuals. The results showed that *O. javanicus* attacked all materials but only white meranti wood (Shorea sp.) that has significant consumption rate measured 0.99 grams/day. White meranti woods containing 40 ppm fipronil were applied as bait to evaluate its effectiveness against *O. javanicus*. The result showed that application of 67.6 grams' bait containing 2.7 mg of fipronil could repress half of *O. javanicus* foraging individuals from 265.350 to 121.245 foragers.

Keywords: albizia wood, cardboards, fipronil bait, food preferences, meranti woods, *Odontotermes javanicus*.

Bachelor of Science

Courtship Communication in the Wolf Spider, *Gladicosa bellamyi*

Madeline M. Lallo and George W. Uetz
Department of Biological Sciences, University of Cincinnati

In spiders, communication is critical for species recognition and mating success (and reduction of sexual cannibalism). Spider communication often involves multiple sensory channels, and sometimes two or more of these sensory channels are combined simultaneously into multimodal communication signals. Wolf spiders (Lycosidae) communicate using multiple sensory modes, including vibratory signals, visual displays, and chemical signals. While many lycosid species communicate with primarily vibratory signals, some species utilize multimodal communication. A species recently discovered in S.W. Ohio, *Gladicosa bellamyi*, exhibits the potential for multimodal communication. Male *G. bellamyi* possess leg pigmentation, suggesting the hypothesis that they utilize visual signals as well as vibration in multimodal courtship signals. Using a laser Doppler Vibrometer, we were able to characterize the vibratory signal of male *G. bellamyi*. A video camera was used to record the visual signals of males and females. Males court females with a staggered walk, as well as waving one or both forelegs in a square leg arch, and produce vibratory signals. Three components of their vibratory signal were discovered, percussion, stridulation, and a third element of unknown origin, combined into a single pulse train. Visual signals of male *G. bellamyi* were similar to the visual signals used by other lycosid species. Female *G. bellamyi* show no apparent vibratory signals, but possess visual receptivity displays similar to other species. We conclude that male *G. bellamyi* exhibits a complex vibratory signal as well as unique and distinct visual signals. Males use both of these modes simultaneously, supporting our hypothesis that *G. bellamyi* uses multimodal courtship communication.

Keywords: sensory channels, multimodal communication, *Gladicosa bellamyi*.

Bachelor of Science

Efficacy of Experimental Repellent (ECS-F-539) Compared to Commercial Insecticide Standards for Managing Spotted Wing Drosophila (*Drosophila Suzukii*)

Benjamin A. Savage

Department of Entomology, Purdue University, West Lafayette, IN 47907

Spotted wing drosophila (*Drosophila suzukii*) is an invasive pest species of vinegar fly found throughout North America and Europe. This insect infests many fruits such as blueberries, blackberries, cherries, grapes, peaches, raspberries, strawberries and more by laying their eggs within healthy fruits as they are ripening. The eggs that hatch release maggots that render the fruits unmarketable by feeding on the fruits and then contaminating them. The objective of this project was to investigate the use of a naturally produced compound to repel populations of this insect. The experimental repellent, ECS-F-539 (Locus Agricultural Solutions, Greater San Diego Area, CA), has shown a high degree of efficacy in laboratory conditions to protect small fruits from *D. suzukii* oviposition. The repellent was tested against two commercial standards, Delegate (Dow Agrosciences, Indianapolis, IN) and Mustang Maxx (FMC, Philadelphia, PA), along with an untreated control on raspberries at the Throckmorton Purdue Agricultural Center. The experiment was arranged in a randomized complete block design with four replications. Each experimental unit was 20 feet of a row of raspberries. Two successive applications were applied with a handheld, CO_2-powered backpack sprayer. Then the fruit were classified as either infested or uninfested after being picked, returned to the laboratory and examined. After analyzing the data, there were no significant differences between the percentages of uninfested fruit and the other treatments in this study. Because we know that commercial growers are receiving good to excellent control with the standards in our trial, one can conclude that our application method was not providing sufficient coverage to protect the fruit from oviposition. The repellent, ECS-F-539, did not reduce the percentage of infested fruit compared to the untreated control, suggesting that it may also require improved spray coverage or an adjusted application rate to provide acceptable levels of control.

Bachelor of Science

Osiris Genes Expression in Harvester Ants and German Cockroaches

Swati Pant, Moataz Noureddine, Chris Smith

Earlham College

The Osiris gene family is a cluster of genes present in all insect genomes and is the result of multiple ancient duplications of a single ancestral gene (the cluster typically includes twenty Osiris genes). The order of the genes is highly conserved among insects, and deletions of the cluster are fatal. Our experiment focused on the expression of multiple Osiris genes in *Pogonomyrmex barbatus*, harvester ants, and *Blattella germanica*, the german cockroach. The choice of these two species is strategic and allowed us to examine expression patterns in organisms with very different lifestyles. The ants have complete metamorphosis and are social while the cockroaches have incomplete metamorphosis and are solitary. Therefore, we were able to examine how Osiris gene expression correlated with different phenotypes and across different types of development - preliminary data suggested that Osiris genes had high expression in pupae. We assayed gene expression in whole bodies spanning developmental stages using quantitative polymerase chain reaction (qPCR). For the harvester ants, gene expression was highest in the worker pupa, and almost completely absent in queens, while expression was highest in the last nymphal instar of the cockroach. Therefore, in both species, Osiris expression peaks in the transition to adulthood, and in the social species, it is only expressed highly in the worker caste. These results suggest that the expression pattern of these genes was co-opted into the pupal phase from the penultimate instar of insects with incomplete metamorphosis, and further co-opted into the evolution of the worker caste.

Bachelor of Science

The Role of HATs and HDACs in *Sarcophaga bullata* Diapause Phenotype

Robin Bautista Jimenez, Julie Reynolds, David Denlinger

The Ohio State University

Diapause is an alternative developmental pathway in insects, similar to hibernation in mammals, used to avoid periods of uninhabitable conditions. Diapause phenotype may be regulated by epigenetic mechanisms which can alter the phenotype without changing the DNA sequence. This project aims to determine if and how histone deacetylases(HDACs), histone acetyltransferases (HATs), and other histone modifiers act as epigenetic mechanisms to regulate diapause in *Sarcophaga bullata*. It has previously been shown that histone modification affects diapause phenotype in Sarcophaga (Reynolds and Denlinger, 2009). Histone acetyltransferases add acetyl groups to histones, often making it more accessible to translational machinery. Meanwhile, Histone deacetylases remove acetyl groups, allowing the DNA to form a tighter coil. This tightening makes the DNA less accessible to transcriptional machinery. We predict that modification of histones by histone acetyltransferases and histone deacetylases will affect the diapause phenotype. Using quantitative real-time PCR (qRT-PCR) to assess expression of HDAC and HAT genes in early diapause, mid, late diapause, and non-diapause flies we expect to elucidate the role of HDACs and HATs in diapause. Several genes in our gene library were differentially expressed in the different stages of diapause and/or between diapausing and non-diapausing pupae suggesting they play important roles in diapause phenotype. Based on the expression patterns across diapause of these genes were are now better able to understand how they might work to control the diapause phenotype.

Bachelor of Science

Revision of Diagnostic Morphological Traits in Four Caribbean Species of Heterotermes (Isoptera: Rhinotermitidae)

Zachary H. Griebenow, Susan C. Jones, and Tyler Eaton

The Ohio State University

Termites of the genus Heterotermes Froggatt (Rhinotermitidae: Heterotermitinae) are pantropical subterranean wood-feeders capable of causing significant structural damage. Despite their economic importance, the taxonomy of Heterotermes remains understudied due to a lack of robust morphological characteristics enabling reliable identification. The aim of this study was to investigate a range of morphometric attributes, two of them novel, in four putative Caribbean species of Heterotermes previously identified by sequencing of three genes. All samples were from Puerto Rico and genetically attributed to either *Heterotermes cardini* (Snyder), *H. convexinotatus* (Snyder), *H. tenuis* (Hagen), or an undescribed Heterotermes sp. Only members of the soldier caste were examined. Soldiers (n=99) were imaged and measurements made using the image-stacking AutoMontage program. Preliminary results demonstrated that measures of the pronotum and head were useful for species identification, and thus this aspect of termite anatomy was singled out for extensive investigation. Five morphometric indices were measured on each specimen: the ratio of head width to length, pronotum width to length, head capsule length to mandible length, and the respective depths of the anterior and posterior notches. These latter two metrics are novel to this study. Future work will use ANOVA, discriminant, and cluster analyses to determine which trait or combination of traits are of most utility in enabling reliable identification of Puerto Rican Heterotermes to species level. This will aid our understanding of the species-level biology and control of this economically significant group.

Bachelor of Science

Developing New, Safer Insecticides for Control of Arbovirus-Vectors: Mosquitoes

Jasleen Kaur and Catherine A. Hill

Department of Entomology, Purdue University, West Lafayette, IN 47907

Aedes aegypti, a type of mosquito, spreads number of diseases related to arboviruses. Control of mosquitoes and arboviral diseases depends largely on insecticides, but recent studies show development of resistance pyrethroids in mosquitoes. G-protein coupled receptors are targets of new mode of action insecticides. Along with new mode of action insecticides, synergism between two different classes of insecticides may increase toxicity of insecticide and prolong development of resistance. Dopamine receptor antagonist amitriptyline and Cis(z)flupenthixol were used in larval bio-assay in vitro, at different concentrations. All bioassays were ran for 72 hours, and mortality was recorded as lack of movement in mosquito larvae. Further, dose response curve show relationship between dosage of antagonist and percent mortality caused at certain time period. Larval bioassay allowed to investigate compounds in aquatic stage of mosquito, and adult blood-feeding assay help understand the use of compound systemically. In adult blood-feeding assay, compounds were added directly to defibrinated rabbit blood and given to adult mosquitos through a hemotech device. After one hour of feeding, non-fed females and male mosquitoes were removed from the cage. Fed female mosquitos were monitored for 72 hours to examine the rate of mortality per dosage and later they were provided with egg cups to observe the impact of dose on fecundity. Systemic insecticides may help to repel mosquitos and lower the risk of transmission of disease caused by arbovirus.

Master of Science

Response of Adult *Anoplophora Glabripennis* (Coleoptera: Cerambycidae) to Isothiocyanates

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[2]Department of Biology, Xavier University, 3800 Victory Parkway, Cincinnati, OH 45207

[3]Departments of Biochemistry and Molecular Biology and Computer Science and Engineering, Michigan State University, 603 Wilson Road, East Lansing, MI 48824

The Asian longhorned beetle (ALB), *Anoplophora glabripennis* Motschulsky, is a serious woodboring pest that has become established outside of its native range in several locations in North America and Europe. If left unmanaged, ALB is estimated to be capable of destroying over 30% of urban tree canopy cover in the United States and inflicting millions of dollars in damage. Unfortunately, successful monitoring and management of ALB has been hindered by a lack of highly attractive lures. Identifying novel insect produced semiochemicals may lead to more effective lures and improve trap efficacy. Recent genomic evidence suggests the presence of a number of genes that encode enzymes of the beta-glycosyl hydrolase GH1 family, some members of which produce isothiocyanates (ITCs). Although these compounds play a role in intraspecific communication in several insect taxa, their function in ALB chemical communication remains unknown. Here we describe the results of laboratory bioassays testing the response of adult ALB to allyl ITC, iso-butyl ITC, phenyl ITC, and methyl ITC in a Y-tube olfactometer. Our results demonstrate that ALB responded to allyl ITC, but did not respond to the other ITCs tested. The identification of ITCs attractive to ALB may serve to enhance current monitoring and detection efforts for ALB infestations.

Master of Science

A Preliminary Phylogeny of *Eudocima* Based on Morphological Data (Lepidoptera: Erebidae: Calpinae)

Crystal Klem[1], Alberto Zilli[2], and Jennifer Zaspel[1]

[1] Department of Entomology, Purdue University, West Lafayette, IN 47907

[2]The Natural History Museum, Life Sciences, DC2-2N, Cromwell Road, London SW7 5BD, UK

Fruit-piercing moths in the genus *Eudocima* are distinctive due to their bright coloration and significant pest status. There are at least 44 *Eudocima* species, which are cosmopolitan, and can be found throughout the New World tropics, Asia, Africa and Australasia; they have been noted as severely damaging pests in these regions as early as 1869. Many consider the current *Eudocima* classification as artificial, and there are many suspected species complexes. Despite this, no comprehensive phylogeny or revision of the genus exists. In this study, a preliminary phylogenetic analysis of *Eudocima* [Lepidoptera: Erebidae: Calpinae] is conducted using morphological characters to examine support for historical groupings of *Eudocima* in multiple genera. A morphological data matrix with 70 characters is compiled for 49 ingroup terminals representing 39 *Eudocima* species. The resulting data matrix is analyzed using parsimony with one single most parsimonious tree obtained, and parsimony ancestral state reconstruction of morphological characters was implemented. Results from the analysis based on morphological data show that *Eudocima* forms a monophyletic clade with several strongly supported clades found within the genus. Species within these clades show character consistency that can be summarized in trends, but historical genera were not recovered in separate clades. These results suggest that phylogenetic evidence does not support historical groupings in multiple genera, and more work is needed to elucidate the phylogenetic relationships within *Eudocima*.

Master of Science

Effects of Reciprocal Grafting of Resistant and Non-Resistant Ash Species on Emerald Ash Borer Survivorship and Herbivory

Sara Stack, Matthew Ginzel, and Clifford Sadof

Department of Entomology, Purdue University, West Lafayette, IN 47907

Emerald ash borer (EAB; *Agrilus planipennis* Fairmaire Coleoptera: Buprestidae) is an invasive phloem-boring pest from Asia that has killed tens of millions of North American ash (*Fraxinus* spp.) trees. In its native range, ash trees are resistant to EAB herbivory due to secondary defensive compounds, but all species of North American ash are susceptible to EAB. Previous studies investigating host plant resistance in ash have been conducted on un-grafted trees, but most of the estimated 17 million urban ash trees at risk from EAB infestation are grafted on susceptible green ash rootstock. The purpose of this study was to investigate the effects of the reciprocal grafting of resistant and non-resistant species of ash on adult emerald ash borer herbivory and survivorship. This study was conducted in the field on reciprocal and conspecific grafts of green (*Fraxinus pennsylvanica* Marsh.*)*, black (*Fraxinus nigra* Marsh.), Manchurian (*Fraxinus mandschurica* Rupr.), and Chinese (*Fraxinus chinensis* Roxb.) ash in Indiana in June and July of 2016. Data were analyzed to both test hypotheses about herbivory and survivorship, as well as to assess the robustness of our field methods.

Master of Science

The Effects of Habitat on the Courtship Signal Active Space of Two Wolf Spiders

Pickett, E. and Uetz, G.W.

University of Cincinnati

Habitat may place constraints on animal communication. Two closely related lycosid species, *Schizocosa ocreata* and *S. rovneri,* are similar in morphology, yet are reproductively isolated by courtship behavior and microhabitat. Male *S. ocreata* exhibit multimodal courtship signals (visual and vibratory) and occupy complex upland deciduous forest litter, whereas male *S. rovneri* use unimodal (vibratory) signals and are found in compressed floodplain litter. To explore differences in the active space of male courtship signals for both species, we used female orientation as an indicator of signal transmission in mesocosms representing the native habitat of each species. Males of both species were randomly assigned to each mesocosm type. Females were restrained in a clear acetate ring at one end of the mesocosm, and paired with conspecific males for an hour or until the female oriented towards the male. Species differed in orientation latency and distance overall; female *S. rovneri* had longer latency and shorter orientation distance. However, no significant differences were found within species for orientation distance or latency between mesocosm types. To further investigate the impact of the environment on the propagation of male courtship signals, a field study was conducted using laser Doppler vibrometry (LDV) to determine the vanishing point of vibratory signals for *S. rovneri* to compare to existing data for *S. ocreata*. It was found that the average vanishing point of *S. rovneri* in the floodplain (>20cm) was greater than the average vanishing point of male *S. ocreata* in the upland, deciduous forest habitat as described by previous studies. Taken together, the shorter vanishing point of *S. ocreata* vibratory signals, yet greater female orientation distance regardless of mesocosm, suggests that the visual component of the multimodal signal of *S. ocreata* acts to increase courtship active space.

Keywords: behavior, sexual selection, communication, vibration, microhabitat, arachnids

Master of Science

Thousand Cankers Disease: Scolytine Beetles Associated with Symptomatic Eastern Black Walnut (*Juglans Nigra*)

Tyler Stewart[1], Margaret McDermott-Kubeczko[2], Jennifer Juzwik[3] and Matthew Ginzel[1]

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Thousand cankers disease (TCD) is a pest complex formed by the association between the walnut twig beetle (WTB), *Pityophthorus juglandis* (Coleoptera: Curculionidae: Scolytinae), and the fungal phytopathogen *Geosmithia morbida*. TCD is responsible for the widespread death of black walnut trees throughout the West. Currently the pest complex has been confirmed in six eastern states within the native range of black walnut (*Juglans nigra*). Here, I present current work characterizing the assemblage of scolytine beetles and weevils associated with symptomatic black walnut trees in Butler Co., Ohio, an essential step in understanding the etiology and epidemiology of this disease complex. In 2014 and 2015, we reared scolytine beetles from stem and branch sections of four TCD-symptomatic trees each year to determine the extent to which other insects might transmit the pathogen. We recovered eight predominant beetle taxa and detected *G. morbida* from five bark and ambrosia beetle species, including the invasive *Xylosandrus crassiusculus* and *Xyleborinus saxeseni*. In summary, a suite of insect species colonizes black walnut as TCD develops and may be capable of transmitting *G. morbida*.

Master of Science

Towards Quantifying Differences in the Ecological Value of Native and Exotic Trees Within Cleveland's Urban Forest

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The Ohio State University

Vacant land, a product of population and economic decline resulting in the abandonment of infrastructure, has increased substantially in shrinking cities around the world. In Cleveland, Ohio, vacant lots are minimally managed, concentrated within low-income neighborhoods, and support a large proportion of the city's urban forest. We quantified abundance, richness, diversity, and size class of native and exotic tree species on inner-city vacant lots, inner-city residential lots, and suburban residential lots, and used i-Tree Eco to model the quantity and economic value of regulating ecosystem services provided by their respective forest assemblages. Inner-city vacant lots supported three times as many trees, more exotic than native trees, and greater tree diversity than inner-city and suburban residential lots, with the plurality of trees being naturally-regenerated saplings. The urban forest on inner-city vacant lots also had two times as much leaf area and leaf biomass, and more tree canopy cover. The quantity and monetary value of ecosystem services provided by the urban forest was greatest on inner-city vacant lots, with exotic species contributing most of that value, while native taxa provided more monetary value on residential lots. We conclude that the predominately naturally-regenerated, minimally managed exotic tree species on vacant land provide valuable ecosystem services to the inner-city neighborhoods of Cleveland, OH. Future research efforts should focus on assessing the conservation value these exotic tree taxa for native fauna.

Master of Science

Biogeochemical Interactions Between an Invasive Scarab (*Popillia japonica* Newman) and its Subterranean Environment

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The goal of this project is to gain a better understanding of the interactions between invasive Japanese beetle (JB) larvae and their subterranean environment. In support of this goal, we quantified the impact of JB larvae on soil microbial activity (CO_2 flux) and functional diversity (phospholipid fatty acid analysis) in soil microcosms and characterized the microbiota of 1st and 3rd instar larval guts via 16S rDNA sequencing. Findings suggest that JB larvae cause significant and lasting changes to soil microbial diversity and activity; weakening soil fungal and protozoan populations and shifting microbial populations toward bacteria. These changes resulted in increased microbial activity, potentially liberating larger amounts of CO_2 from the soil. Analysis of 16S microbial rDNA revealed taxonomic and functional differences in the microbiota of 1st and 3rd instar larval guts with ammonia oxidizing, nitrogen fixing and organic residue-degrading gut endosymbionts dominating the community and a notable shift toward taxa that are commonly associated with the soil as larval development proceeded. Results suggest that JB infestations may reduce soil organic matter and increase soil CO_2 emissions and imply that interactions between JB larvae and the soil are, in part, microbially-mediated, which could have implications for pest management.

Master of Science

Cumulative Oxygen Consumption During Development of Two Postharvest Pests (*Callosobruchus Maculatus* Fabricius and *Plodia Interpunctella* Huebner)

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Insect pests cause substantial losses during postharvest storage. Major storage insect pests include the Indian meal moth (*Plodia interpunctella* Huebner*),* the maize weevil *(Sitophilus zeamais* Motshulsky*),* the cowpea bruchid *(Callosobruchus maculatus* Fabricius*),* and the larger grain borer (*Prostephanus truncatus* Horn). Hermetic storage is among the most successful solutions being used by smallholder farmers in Asia and Africa, to protect harvested grain from insect pests. With the increased use of hermetic technologies comes a need to understand the biology of specific storage pests and their responses to hypoxia. In the present study, we employed a non-invasive analytical technology, and evaluated the OxySense 5250i as to its effectiveness in measuring the lifetime oxygen consumption of two insect pests: cowpea bruchid (CPB) and Indian meal moth (IMM). We found that the CPB consumes approximately 9.0 ± 0.4 mL of oxygen per insect over its larval developmental period (29.7 days). These results were not significantly different from those previously recorded using other methods. We found that the IMM consumes approximately 26.94 ± 0.7 mL of oxygen per insect over its larval developmental period (37.11 days). Interestingly, the CPB and the IMM consume oxygen at a similar daily rate. Information on the lifetime oxygen consumption of the CPB and the IMM adds to our understanding of insect physiology, and allows for an assessment of the effectiveness of hermetic technology and its ability to provide protection against major postharvest insect pests.

Master of Science

Attraction of *Pityophthorus Juglandis* to Volatiles of *Geosmithia Morbida* – The Causal Agent of Thousand Cankers Disease

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Thousand cankers disease (TCD) is a pest complex formed by the association between the walnut twig beetle (WTB), *Pityophthorus juglandis* (Coleoptera: Curculionidae: Scolytinae), and the fungal pathogen *Geosmithia morbida*. TCD has caused widespread death of walnut trees throughout the West and has recently been introduced to the midwestern and eastern US, and threatens black walnut (*Juglans nigra*) throughout its native range. Currently, monitoring and detection efforts for WTB rely on a pheromone lure that is effective from a limited distance, while plant- and fungal-derived volatile organic compounds (VOCs) that may facilitate host location remain poorly understood. Previous work established that WTB are more attracted to volatiles emitted from girdled limbs of black walnut than intact branches. In this study, we performed Petri dish bioassays to test the hypothesis that adult beetles are attracted to volatiles of *G. morbida*. By measuring residence time in treated areas, we determined that male and female beetles were attracted to *G. morbida* solvent extracts over a potato dextrose agar (PDA) control. We characterized the VOCs of *G. morbida* and, through behavioral bioassays, discovered a suite of pathogen-specific compounds that are attractive to WTB. Identification of volatiles that attract WTB will lead to the development of an improved lure used to enhance current detection and monitoring efforts to preserve black walnut.

Keywords: walnut twig beetle, Scolytinae, volatile organic compounds, *Juglans nigra*, vector

Doctor of Philosophy

Spatiotemporal Associations Between Herbivory and Neonicotinoid Insecticides in Milkweeds Neighboring Agricultural Land

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Pesticides can move from crops into wild plants growing in neighboring unmanaged areas. This is the case for milkweeds growing around agricultural areas in the Midwestern U.S. that host a diversity of native insects, including the monarch butterfly. However, the non-target contamination of milkweeds from adjacent agricultural fields is relatively unknown and it remains unclear whether this serves as a potential conservation risk. We surveyed the milkweed associated herbivores on plants at varying distances from corn fields and estimated herbivory from five sites in Indiana over three sample periods in June, July, and August. Simultaneously, we tagged, georeferenced, and collected milkweed leaves and tested them for pesticides residues. The percentage of herbivory varied from 15-70% of total leaf tissue consumed and was higher on plants growing further away to field edges. The main seed treatment used on corn, clothianidin, was present in 3-61% of milkweed samples collected early in the season (concentration= 0.322 ng/g), depending on site and distance from corn fields. This is within the levels previously reported to have sublethal effects on monarch development. Other neonicotinoids (e.g., imidacloprid, thiamethoxam, acetamiprid) were also detected in our samples that likely originated from nearby soybean fields or horticultural crops. In general, the incidence of clothianidin was strongly correlated with distance from the edge of corn fields. Other pesticides however were not correlated with distances, this suggests that other factors (e.g., directionality, soil type, genetic variation in plant traits affecting insecticide uptake) need to be factored into non-target predictive models.

Doctor of Philosophy

Identifying Genes Involved in Pheromone Biosynthesis in *Neoclytus Mucronatus* (Coleoptera: Cerambycidae) Using a Differential Gene Expression Approach

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The longhorned beetles (Coleoptera: Cerambycidae) are among the most economically important pests of natural and managed forest systems worldwide. Many species produce volatile pheromones to unite the sexes on an appropriate host, and display a characteristic posture while releasing pheromone, or "calling." Pheromones have been identified for several species and are used in monitoring efforts, but little is known about the biosynthesis of cerambycid pheromones. In this study, we used a differential gene expression approach to identify genes that may be involved in pheromone production. Total RNA was extracted from male *Neoclytus m. mucronatus* that were either 1) dormant in the morning before dawn, 2) actively calling at noon or 3) actively feeding beetles that were not calling at noon (n=3 for each group). We tested the hypothesis that transcripts from pheromone biosynthetic genes are expressed at higher levels in actively calling than in resting beetles. A total RNA library was constructed from the extracts using RNAseq, and the relative expression levels between each treatment were compared using edgeR and DESeq2 packages in R/Bioconductor. We found 61 contigs that were differentially expressed between the predawn and noon treatments, 56 contigs that differed between the predawn and calling treatments, and 23 contigs that differed between the noon and calling treatments. Among the differentially expressed contigs were a short-chain dehydrogenase/reductase resembling a pheromone biosynthetic gene found in *Musca domestica*, and a cytochrome P450 that closely resembles CYP18A1 in *Tribolium castaneum*. Understanding genes and key enzymes in the biosynthetic pathway may open new avenues for controlling these pests.

Doctor of Philosophy

Identifying Changes in Gene Expression That May Promote Virulence in the Soybean Aphid, *Aphis Glycines*

Ashley Yates, Raman Bansal, Vitor Correa Pavinato, and Andy Michel

The Ohio State University

Insects have evolved mechanisms to evade plant defenses, facilitating their survival and proliferation. Plant cultivars that are resistant to insects through host-plant resistance are better protected from herbivory and offer an environmentally safe tool for pest management. Host-plant resistance is used against the most damaging insect pest of soybean: the soybean aphid, *Aphis glycines*. However, some populations of *A. glycines* can overcome resistance (i.e. virulent), threatening host-plant resistance durability. The mechanisms of aphid virulence to resistant soybean are mostly unknown, but previous research indicates that these mechanisms may involve detoxification and secretion of putative effector proteins to facilitate host plant colonization. Our objective is to identify genes that may play a role in *A. glycines* virulence. We hypothesize that virulent aphids differentially express putative effector protein genes. To identify potential mechanisms of aphid virulence, we performed RNA-sequencing of avirulent and virulent aphids fed susceptible or resistant soybean varieties. We found 32 and 11 putative effector genes differentially expressed in virulent aphids (relative to avirulent) fed susceptible or resistant soybean, respectively. These putative effectors are mostly down-regulated in the virulent aphid, regardless of the plant variety the virulent aphid was fed. When the virulent aphid was fed *susceptible* soybean, the down-regulated putative effectors have predicted functions of protein folding/binding, protein secretion, chitin binding and calcium binding. When the virulent aphid was fed *resistant* soybean, few putative effectors were down-regulated, including 2 genes with peptidase activity. Overall, these genes are known to help facilitate aphid feeding. However, as these genes are down-regulated in the virulent aphid, we hypothesize that the virulent aphid down-regulates putative effectors to evade plant defenses. Future research will include functional analysis of putative effectors using RNA interference, and transcriptome-wide differential gene expression analysis between avirulent and virulent aphids.

Doctor of Philosophy

Identification of Proteins Required for Successful RNA Interference in the Colorado Potato Beetle, *Leptinotarsa Decemlineata*

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The efficacy of RNA interference (RNAi) is variable among insects studied. We identified a cell line, Lepd-SL1, developed from Colorado potato beetle (CPB), *Leptinotarsa decemlineata that* takes up dsRNAs without any chemical supplements and is indeed highly sensitive to RNAi: Using 'RNAi of RNAi' approach, we screened 50 genes with potential functions in uptake, intracellular transport, and processing of double-stranded RNA (dsRNA). Among 29 genes identified as those required for RNAi, silencing of five genes (Argonaute-1, Argonaute-2a, Argonaute-2b, Aubergine and vacuolar H+ ATPase 16 kDa subunit 1, Vha16) blocked RNAi, suggesting that these genes are essential for functioning of RNAi in Lepd-SL1 cells. Interestingly, Argonaute-1 and Aubergine are known to be associated with miRNA and piRNA pathways respectively were found to be essential for siRNA pathway as well. Moreover, the duplicated argonute2 and dicer2 genes also participate in RNAi pathway. These data suggested that efficiency of successful RNAi may depend on from multiple functional core RNAi machinery genes. Using ^{32}P labeled dsRNA, we showed that Argonaute-1 and Aubergine are involved in the processing of dsRNA into siRNA. Our study identified key factors involved in successful RNAi operating in Lepd-SL1 cells.

Doctor of Philosophy

Public Attitudes on Monarch Conservation

Jerrod M. Penn[1], Hannah J. Penn[2], and Wuyang Hu[1]

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Education has been shown to alter the public's opinion of conservation in general and beneficial and pest species specifically as public attitudes are often based on social pressures. The monarch butterfly is often used as a teaching device in schools and outreach events due to its annual continental voyage to reach its overwintering grounds. Additionally, its vibrant color makes it more popular relative to other insects. However, due to concerns over its loss of habitat from logging in the Mexican over-wintering sites and loss of food resources in the vast majority of its summer range due to herbicide application in agricultural fields, the decline of monarch populations has been of concern, so much so that the US Fish and Wildlife is evaluating whether to place monarchs on the list of threatened/endangered species in the United States. We wanted to determine the general public's views on monarch conservation and the role that milkweed plays in sustaining their populations. We surveyed public park attendees to assess their knowledge of the species and its food needs, respondent ability to identify a monarch, and what other factors may affect their opinions about monarch conservation efforts such as planting milkweed. We found that about 40% of participants could identify a monarch/viceroy from a lineup of other butterflies, but only 40% could correctly identify a monarch. Respondents generally had heard about monarchs but were relatively unaware of their population declines and the necessity of milkweed to their life cycle. The outcomes of our study inform future education needs in order to later increase the public's desire for insect conservation particularly at a local scale where previous survey results indicate are most wanted.

Doctor of Philosophy

Developmental Differences in Olfactory Processing for Predaceous Insects

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The spined soldier bug, *Podisus maculiventris*, is a polyphagous predator likely using herbivore-induced plant volatiles (HIPVs) for foraging. We hypothesize that conditioning this predator to HIPVs may increase their efficiency as biocontrol agents. However, little is known about olfactory conditioning in predaceous insects. Assuming a response by *P. maculiventris* to HIPVs is acquired via associative learning, we trained individual predators to associate a conditioned stimulus (the synthetic HIPV methyl salicylate, or MeSA) with an unconditioned stimulus (hemolymph extracted from the tobacco hornworm *Manduca sexta* as food), expecting attraction to this volatile when paired with a food reward. After experiencing this association, we assessed adult and nymph preferences toward MeSA. We found that: 1. Conditioned nymphs showed an orientation response to MeSA whereas adults did not display a strong preference upon conditioning, suggesting that olfactory learning abilities may vary with developmental stage; 2. Nymphs that responded positively to MeSA retained this association for ca. 48 hrs which might indicate short term memory, habituation and/or replacements of olfactory templates; and 3. The response of nymphs was the same regardless of the number of volatile-food pairings (i.e., one vs. multiple association experiences). Overall, our results provide evidence that *P. maculiventris* nymphs learn to associate HIPVs with prey presence and they are more likely to respond to conditioning protocols; nevertheless, the information they acquire appears to be rapidly modified. These findings suggest that immature stages outperform adults when designing pest management practices that enhance the beneficial effects of HIPVs on biological control.

Doctor of Philosophy

Efficacy of Horticultural Oil and Insecticidal Soap on Soft and Armored Scale Insects

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Smothering agents, such as insecticidal soap and horticultural oil, have the potential to reduce populations of soft bodied insect pests with minimal effects on beneficial insects, due to their short residual activity as contact insecticides. In practice, efficacy of oil and soap against armored and soft scales has been inconsistent. This research was conducted to determining how efficacy is influenced by 1) whether the pest is a soft (Coccidae) or armored (Disaspididae) scale and 2) the life stage of the target organism. We then determined if honeydew accumulation by soft scales would reduce the efficacy of oil or soap. We chose calico scales and pine needle scales to represent species who produce a single large cohort of eggs that produce crawlers over a short period of time. We then chose striped pine scale and oleander scale to represent species who lay several eggs a day and produce crawlers over a longer time interval, and are likely to have overlapping generations. Our field and laboratory studies suggest that both horticulture oil and insecticidal soap kill soft and armored scale insects when applied at the verdant rate (2%) during the active crawler stage; however, they both lose efficacy after scales have settled and over time. Overall, horticulture oil provided better control against armored scales than soft scales, whereas insecticidal soap gave better control against soft scales. Because the toxicity of these products are stage specific, other sources of mortality, such as biological control, will be critical to successfully manage species with overlapping generations.

Doctor of Philosophy

Chemically-mediated Host Selection and Colonization Behavior of the Peach Bark Beetle, *Phloeotribus Liminaris* (Coleoptera: Scolytinae)

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The peach bark beetle (PBB), *Phloeotribus liminaris*, is native to North America where it is a common pest of black cherry trees (*Prunus serotina*). Adult beetles colonize branches and stems where they bore through the bark to feed on the nutrient-rich phloem. In response to insect attack, the tree produces a resinous gum to pitch out colonizing beetles. This defensive response permanently stains the wood, making it unsuitable for veneer, thereby reducing its value. PBB spends the majority of its life cycle hidden beneath the bark where it is protected from sprayed insecticides. However, semiochemicals may hold promise for monitoring and controlling populations. In this study, we tested the hypothesis that adult PBB locate suitable hosts by orienting to cherry volatiles, and sexes are united by attraction to aggregation pheromones. To determine attraction of adult PBB to host volatiles, traps baited with benzaldehyde, a common volatile of cherry, were placed in mixed hardwood forest in northern Indiana and number of captured PBB was recorded. To determine whether PBB produce an aggregation pheromone, we conducted a field experiment using traps baited with bolts of cherry infested with either male or female beetles. In these experiments, adult PBB were attracted to both the cherry volatile benzaldehyde and female-infested bolts of cherry, suggesting that females produced a volatile aggregation pheromone. Information on the colonization behavior of PBB will aid in establishing effective management programs, including the use of pheromones and host volatiles as lures to detect, monitor, and manipulate pest populations.

Appendix I: Past Winners of the Annual Forum for the Student Paper Competition

Undergraduate Competition			
Year	**First Prize**	**Second Prize**	**Third Prize**
1985	D. Craig Heim University of Kentucky	Valerie Kugler Earlham College	Raymond E. Siegel Purdue University
1986	Sunedha Weeratunga University of Kentucky	Timothy Coppess Anderson University	Not awarded
1988	Kathy A. Mitktuk University of Kentucky	David Rivers Ball State University	Not awarded
1989	Douglas D. Anspaugh Purdue University	Margaret Buxton University of Kentucky	Britt Bunyard Kent State University
1990	Jaime D. Coots Anderson University	Shephen R. Skaggs Northern Kentucky University	Peggy Sue Merchant Earlham College
1991	Kenneth W. Blank Northern Kentucky University	Corey R. Gerber Purdue University	Russell May University of Kentucky
1992	Betty Krueger University of Kentucky	Thomas O. Swinford IU-PU Fort Wayne	Judy Neff Purdue University
1993	Carl Harper University of Kentucky	Not awarded	Not awarded
1994	Jason Scannell University of Kentucky	Jeff Bedel Purdue University	Michael K. Agenter Northern Kentucky University
1995	Deborah L. Finke Centre College	Jason A. Scannell University of Kentucky	Leslie Horne College of Mt. St. Joseph
1996	Mark Doyle Purdue University	John Shea & Rachel Bartholomew Cleveland Natural History Museum	Leo Niemeier Kentucky State University
1997	Anthony Hanley Kentucky State University	Nicola T. Gallagher College of Mt. St. Joseph	Andrew Nuss Purdue University
1999	Tonja Wilkins Kentucky State University	Tyler Eaton University of Kentucky	Louie Rivers III Kentucky State University
2000	Kara Mobray University of Kentucky	Jennifer Steill Purdue University	Philip Gonista University of Kentucky
2003	Ruth Hagarty Purdue University	Brenda Graves University of Kentucky	Rebecca Baumler University of Kentucky
2004	Eric Rellinger Wittenberg University	Rianna Arcinas Purdue University	Joshua Benoit Wittenberg University
2005	Jacob Ark Wittenberg University	M. Walter Baldauf Purdue University	Jonathan Clark Kentucky State University
2006	John Shukle Purdue University	Zachary Bozic Wittenberg University	Ceryl Lindsay (tie) University of Kentucky Justin Tank (tie) Wittenberg University
2007	Justin Tank Wittenberg University	Megan Meuti The Ohio State University	Chad Andrews College of Mt. St. Joseph
2008	Megan Meuti The Ohio State University	Michal Chambers Wittenberg University	Matt Paschen Purdue University
2009	Nikki VanDerLaan Purdue University	Zachary Phillips The Ohio State University	Jeffery Hardesty The Ohio State University

Undergraduate Competition			
Year	**First Prize**	**Second Prize**	**Third Prize**
2010	Peter Martin Goshen College	Tyler Krause Ohio State University	James Baulding University of Kentucky
2011	Bethany Hunt University of Kentucky	Lynn Weaver Goshen College	Rachel Gilbert University of Cincinnati
2012	Maggie Williams University of Cincinnati	Rebecca Wilson University of Cincinnati	Charles Dean The Ohio State University
2013	Eric Brown Kent State University	Denita Brown Kentucky State University	Clancy Short The Ohio State University
2014	Katherine Todd Messiah College	Shelby Fulton University of Kentucky	MaLisa Spring Marietta College
2015	Hannah Quellhorst Purdue University	Madeline Lallo University of Cincinnati	Hannah Stewart Purdue University

Master of Science Competition			
Year	**First Prize**	**Second Prize**	**Third Prize**
1985	Joseph E. Huesing University of Kentucky	F. Gordon Carter University of Kentucky	Kevin A. Shufran Univeristy of Kentucky
1986	Wayne G. Buhler Purdue University	Denise Coar Univeristy of Kentucky	Billy Annan Purdue University
1989	Joseph J. Demark Purdue University	C. J. Voglewede Purdue University	Carl T. Redmond University of Kentucky
1990	Lisa S. Whitt University of Kentucky	Alan W. Davidson University of Kentucky	Deborah M. Campero University of Kentucky
1991	C. J. Voglewede Purdue University	Alan W. Davidson University of Kentucky	Harry B. Meyers Purdue University
1992	Jim P. Vandercoevering Purdue University	Barry Pittendrigh Purdue University	Harry B. Meyers Purdue University
1993	Will McClintock University of Cincinnati	Darcy C. Willis Univeristy of Kentucky	Sue Simon College of Mt. St. Joseph
1994	William J. Rowe II University of Kentucky	Scott P. Dideon Purdue University	Corey K. Gerber Purdue University
1995	Kurt D. Saltzmann Purdue University	Aaron C. Anderson University of Kentucky	W. E. Snyder University of Kentucky
1996	R. Chris Stanton The Ohio State University	Betty Krueger University of Kentucky	Margaret Nichols The Ohio State University
1999	Daniel Hemmann University of Kentucky	Blake Newton University of Kentucky	Marisa Griffin University of Kentucky
2000	Lauren Pintor Univeristy of Kentucky	Michael Rodgers University of Kentucky	Bryan Price Kentucky State University
2002	Amanda Staley University of Kentucky	Charlene Rucker University of Kentucky	Tonja Wilkin Kentucky State University
2003	Kimberly Rebek Purdue University	Reid Maier University of Kentucky	Beth Choate University of Kentucky
2004	Shelly Kellogg University of Kentucky	Rebecca Trout University of Kentucky	Justin Vitullo Purdue University
2005	Aerin Land University of Kentucky	Nick Geraci Purdue University	Rebecca Trout University of Kentucky

Master of Science Competition			
Year	**First Prize**	**Second Prize**	**Third Prize**
2006	Ye Ye The Ohio State University	Paul Marquardt Purdue University	Thelma Heidel (tie) Purdue University Leo Stellwag (tie) Ball State University
2007	Thelma Heidel Purdue University	Ashley Walter Purdue University	Ye Ye The Ohio State University
2008	Annie Spikes Purdue University	Paul Ayayee University of Kentucky	Terri Hoctor Purdue University
2009	Matt Paschen Purdue University	Katie England Purdue University	Gabriel Hughes & Faith Weeks Purdue University
2010	Jonathan Larson University of Kentucky	John Shorter Purdue University	Gabriel Hughes & Nikki VanDerLaan(Tie) Purdue University
2011	Jonathan Larson University of Kentucky	Brent Stoffer University of Cincinnati	Nikki VanDerLaan Purdue University
2012	Nicole Vanderlaan Purdue University	Abiya Saeed University of Kentucky	Sydney Crawley University of Kentucky
2013	Madeline Spigler Purdue University	Kira Albright Purdue University	Devon Rogers The Ohio State University
2014	Andrea Kautz The Ohio State University	Travis Calkins The Ohio State University	Bridget Blood Purdue University
2015	Katherine Todd The Ohio State University	MaLisa Spring The Ohio State University	Alex Styer University of Kentucky Alexandra Duffy Purdue University

Doctor of Philosophy Competition			
Year	**First Prize**	**Second Prize**	**Third Prize**
1985	M. C. Shaw Purdue University	Gary Brookhard Purdue University	David McShaffrey Purdue University
1986	Mark A. Zajac The Ohio State University	S. Kristine Braman University of Kentucky	Sven Strnad Purdue University
1988	Gary A. Braness Purdue University	Donald R. Ross Purdue University	J. Edward King Purdue University
1989	Danise Coar University	Chaoxian Geng Purdue University	Marvin D. Sigal Ohio State University
1990	David L. Clark University of Cincinnati	Wayne G. Buhler Purdue University	Doreen K. S. Goh University of Kentucky
1991	John McHugh Purdue University	Joseph J. DeMark Purdue University	Herbert Eichenseer University of Kentucky
1992	Keyan Zhu Purdue University	Ana I. Soldevila University of Kentucky	Matthew Enrico Bur University of Kentucky
1993	Janet L. Murphy Ohio State University	James D. Wagner University of Kentucky	Robert S. Pfannenstiel University of Kentucky
1994	Constance A. Hallberg Purdue University	Patchanee Tuntibunpakul University of Kentucky	Not awarded

Doctor of Philosophy Competition			
Year	**First Prize**	**Second Prize**	**Third Prize**
1995	Kevin R. Hopper University of Kentucky	F. Anthony DiLuna University of Kentucky	Liwang Cui University of Kentucky
1996	Matthew Persons University of Cincinnati	Sandra DeBano University of Kentucky	Charlotte Bedet The Ohio State University
1999	Patrick Cumrine University of Kentucky	Kenneth Blank University of Kentucky	Eileen Eliason University of Kentucky
2000	Matthew Turnbull University of Kentucky	Valerie Bennet Miami University	Chris Stanton The Ohio State University
2002	Randy Hamilton Purdue University	Eric Rebek Purdue University	Hong Mei Li Purdue University
2003	Al Fournier Purdue University	Eric Rebek Purdue University	Joao Pedra Purdue University
2004	Craig Stillwell University of Kentucky	Michael Seagraves University of Kentucky	Tom Coleman (tie) University of Kentucky Shujan Li (tie) Purdue University
2005	Cynthia Khoo University of Kentucky	Omprakash Mittapalli Purdue University	Michael Seagraves University of Kentucky
2006	Alvaro Romero University of Kentucky	R. Craig Stillwell University of Kentucky	Joshua Benoit The Ohio State University
2007	Joshua Benoit The Ohio State University	Corey L. Brelsfoard University of Kentucky	Tonya Fisher University of Kentucky
2008	Alexzandra Murphy Purdue University	Huh Biah University of Kentucky	Eunho Suh University of Kentucky
2009	Nick Teets The Ohio State University	Kapil Raje Purdue University	Marissa McDonough Purdue University
2010	Nicholas Teets The Ohio State University	Julie Peterson University of Kentucky	Kevin Rice and Elijah Talamas, (Tie) Ohio State University
2011	Alexander Sweger University of Cincinnati	Ignazio Graziosi University of Kentucky	Logan Minter University of Kentucky
2012	Kevin Rice The Ohio State University	Megan Meuti The Ohio State University	Jennifer Gordon University of Kentucky
2013	Gabriel Hughes Purdue University	Kacie Athey University of Kentucky	Sydney Crawley University of Kentucky
2014	Qian Sun University of Kentucky	Liu Yang The Ohio State University	Brittany Peterson Purdue University
2015	Sidney Crawley University of Kentucky	Brittany Peterson Purdue University	Alexander Sweger University of Cincinnati

Appendix II

BYLAWS

Ohio Valley Entomological Association

PREAMBLE

In order to promote the study of entomology as a science; to improve public awareness and understanding; and to recognize the achievements of students and practitioners of entomology, the Ohio Valley Entomological Association has been organized; and to such ends the BYLAWS of which this preamble is a part, are set forth.

Article I

NAME AND DEMOGRAPHICS

Section 1. Name. This organization shall be known as the *Ohio Valley Entomological Association*, hereafter referred to as the **ASSOCIATION**.
Section 2. Demographics. The primary activity of the **Association** shall be restricted to the States of Indiana, Kentucky and Ohio.

Article II

OBJECTIVES

Section 1. The objectives of the **Association** are (1) to promote the study of the science of entomology; (2) to cultivate student interest in the science of entomology and to provide recognition for outstanding achievement; (3) to improve public awareness and better understanding of the science of entomology; and (4) to promote the interaction of interdisciplinary sciences and societies.

Article III

MEMBERSHIP

Section 1. Association membership shall be open to persons interested in entomology.

Section 2. Membership shall be granted by a simple majority vote at a regular meeting to persons who quality under Section 1.

Section 3. Membership privileges. All members shall have equal privileges as to serving on committees, discussion at meetings and participation in **Association** activities.
Section 4. Provisions for Resignation. Any member may resign from **Association** membership effective at the close of any **Association** year. If desired, the resignee may file written reasons

for resignation with the Secretary-Treasurer to become a part of the permanent **Association** record.

Section 5. Termination of Membership. The **Association** reserves the right to terminate the membership of any member upon the recommendation of the Executive Committee after due process, and by a two-thirds vote of the active membership present at any regular meeting.

Section 6. Suspension of Membership. The **Association** reserves the right to suspend membership of any member delinquent in payment of dues in excess of six months.

Article IV

OFFICERS, TERMS, DUTIES, ELECTION AND VACANCIES

Section 1. Officers. Officers of the **Association** shall consist of a PRESIDENT, PRESIDENT-ELECT and SECRETARY-TREASURER. The president and President-elect shall serve a term of one year each, after which the President-Elect accedes to the Presidency. The Secretary-Treasurer shall be elected biennially for a term of two years.

Section 2. Duties. The President shall preside at all **Association** meetings, regular or special. The President shall appoint all necessary special committees and, subject to approval by the Executive Committee, all standing committees necessary for conducting **Association** affairs.

The President-Elect shall assist the President in administrative affairs and assume the presidential duties if the President is absent from a regular or special meeting. In the event a President is unable to complete the term of office for any reason, the President-Elect shall complete that term as Acting President, the immediate Past President shall serve as President-Elect until an election is held.

The Secretary-Treasurer shall make necessary arrangements for **Association** meetings, maintain and distribute to the membership, at least annually, a roster of **Association** members, record all **Association** proceedings, maintain adequate minutes of meeting and attend to general correspondence as may be required. The Secretary-Treasurer shall collect all monies due to the **Association**, pay all bills incurred and maintain adequate records accounting of all **Association** assets. The account shall be audited annually by a committee appointed by the President. In anticipation of an absence from a regular or special meeting, the Secretary-Treasurer shall arrange for an Acting Secretary to assume the prescribed duties.

Section 3. Election of Officers. Officers shall be elected by Active members by a majority vote at the last regular meeting of each **Association** year. A slate of candidates shall be presented by a Nominating Committee prior to the vote. In the event that more than two nominees are presented for an office, runoff balloting shall proceed until one receives a majority of the votes cast. In the event of a tie, the Executive Committee shall be responsible for the administration of an unbiased tie breaking procedure. Newly elected officers will assume office at the last regular meeting of each **Association** year.

Section 4. Vacancies. Vacancy in the office of president and President-Elect shall be filled as provided in Article IV, Section 2. A vacancy in the office of Secretary-Treasurer shall be filled by the Executive Committee for the remaining portion of the **Association** year only, at which time a new Secretary-Treasurer will be elected as provided in Article IV, Section 3.

Article V

EXECUTIVE COMMITTEE

Section 1. Membership. The **Association** executive committee shall consist of the President; Secretary-Treasurer; immediate Past President; and four executive committee Members-At-Large, two of which are elected annually for two-year terms.

Section 2. Election of Executive Committee Members. Executive Committee Members-At-Large will serve two years on the Executive Committee, except two of those initially elected who will serve only one year. Thereafter, two Executive Committee Members-At-Large will be elected annually to succeed those whose terms are expiring.

Section 3. Voting Privilege of Presiding Officer. The presiding officer (see Article IV, Section 2) may vote on matters considered by the Executive Committee only in the event of a tie by the other Committee Members.

Section 4. Duties. The Executive Committee shall have authority to transact necessary **Association** business during the interim between **Association** meeting any business transacted and action taken on behalf of the **Association**. It shall also refer to the **Association** membership all items of business requiring the consideration of action by the membership.

Section 5. Quorum. Five members of the Executive Committee shall constitute the necessary quorum tor the transaction of **Association** business. A majority vote shall be necessary for action of any matter.

Article VI

ASSOCIATION YEAR AND MEETINGS

Section 1. Association Year. The **Association** year shall be the calendar year.

Section 2. Regular Meetings. A special meeting called for any purpose shall be announced by letter from the president or Secretary-treasurer mailed at least 14 days prior to the meeting date.

Section 3. Special Meetings. A special meeting called for any purpose shall be announced by letter from the President or Secretary-Treasurer mailed at least 14 days prior to the meeting date.

Section 4. Quorum. A quorum for the transaction of **Association** business at regular of special meetings shall consist of 20% of the current Active Membership.

Article VII

DUES

Section1. Amount and When Payable. Association dues shall be determined by the Executive Committee and passed by a two-thirds majority vote of the Active Members present at any regular meeting. The Secretary-Treasurer shall notify members by mail before December 20 of each year that dues are payable for the **Association** year. If dues are not received by February 1, one month after becoming delinquent, the Secretary-Treasurer shall mail a second and final notice.

Section 2. Penalty for Non-Payment of Dues. Any member allowing dues to become more the six months delinquent shall be notified by the Executive Committee that the member will be suspended form Active **Association** membership unless delinquent dues are received within six weeks. Reinstatement of active membership shall require payment of delinquent dues plus a 20% penalty.

Article VIII

COMMITTEES

Section 1. Appointment of Committees. The President shall have authority to appoint Special Committees to consider specific items necessary for the transaction of normal **Association** business. Appointments to standing committees whose activities span more than one **Association** year may be made by the President with approval of the Executive Committee.
Section 2. Ex-Officio Membership. The President may serve as an Ex-Officio member of all committees except for the Nominating Committee.

Article IX

AMENDMENT OF BYLAWS

Section 1. Procedure. Amendments to Bylaws may be made by a two-thirds vote of the Active members present at any regular meeting, provided that the membership have been given written notice of the proposed amendment at least 30 days before the meeting during which it will be considered, and provided that a quorum of the members is present (Article VI, Section 4).

Article X

PARLIAMENTARY AUTHORITY

Section 1. The rules contained in *Robert's Rules of Order, Revised,* shall govern this **Association** in all cases to which they are applicable and in which they are not inconsistent with these Bylaws.

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