The Proceedings of the 2022

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and
Invasive Pest Ant Conference

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Edited by
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INTRODUCTION

This publication documents the National Conference on Urban Entomology and Invasive Pest Ant Conference, which took place May 15-18, 2022 in Salt Lake City, UT. This was the 18th NCUE and, like the conferences before, it met its mission to open channels of communication and information between scientists in industry, academia, and government, and to foster interest and research in the general area of urban and structural entomology.

The objectives of NCUE as an organization include:

1. Promoting the interest of urban and structural entomology
2. Providing a forum for the presentation of research, teaching, and extension programs related to urban and structural entomology
3. Preparing written/electronic proceedings of all invited and accepted papers given or prepared at the biennial meeting
4. Promoting scholarship and the exchange of ideas among urban entomologists
5. Awarding scholarships to students pursuing scholastic degrees in urban entomology
6. Hosting an onsite student competition for students who are currently involved in their undergraduate or graduate program

The 2022 NCUE continued to meet all these objectives with new research, students, and attendees. The conference gathered 142 professionals who came with ideas to share and left with new knowledge and a stronger network of colleagues and friends.

The next NCUE & IPA Conference will take place in Mobile, AL in May 2024. The planning committee encourages everyone to keep in touch throughout the years by joining the NCUE Facebook Group and subscribing to the mailing list.

TABLE OF CONTENTS

AWARDS PRESENTATIONS

DISTINGUISHED ACHIEVEMENT IN URBAN ENTOMOLOGY
THE ARNOLD MALLIS MEMORIAL AWARD LECTURE

Ecological and Physiological Adaptations and Management of Urban Insect Pests

Chow-Yang Lee

University of California, Riverside

I am honored to receive the Distinguished Achievement Award in Urban Entomology and deliver the Arnold Mallis Memorial Award Lecture. I am humbled as many of the past awardees are *my heroes* in the field of urban entomology whom I admired and respected, including Walter Ebeling, Mary Ross, Donald Cochran, Gary Bennett, Michael Rust, Coby Schal, Nan-Yao Su, Don Reierson, and Ed Vargo. Growing up in a sleepy hollow town in southern Malaysia, I dreamed of pursuing my graduate studies at UC Riverside (UCR) after my undergraduate degree. Family financial constraints, however, prevented the plan; hence I continued my graduate studies in Malaysia. Soon after completing my Ph.D., I took up a lectureship position at Universiti Sains Malaysia. In 2019, I joined UCR as a faculty member. I was thrilled that 25 years later, I made it to UCR, not as a graduate student but as a professor. Life truly works mysteriously.

My research focuses on ecological, behavioral, and physiological adaptations of urban insect pests such as cockroaches, bed bugs, subterranean termites, and pest ants. I investigate the unique traits (e.g., morphological, behavioral, and biological traits, insecticide resistance, etc.) that enable them to thrive in the urban environment and explore how these findings could be practically applied to manage these pests. For this lecture, I will only concentrate on bed bugs.

Bed bugs have become an important group of urban insect pests in many parts of the world. The importance of bed bugs as a major pest is reflected in the exponential increase in the number of peer-reviewed papers on bed bugs from 1912 to 2022. Approximately US$1 billion is estimated to be spent yearly on bed bug management in the US alone. Bed bug infestations have been reported in residential and public accommodations, buses, trains, airplanes, etc. Over the last 20 years, the pest management industry worldwide has seen a drastic increase in the bed bug market segments (Doggett et al. 2018).

Two bed bug species are important globally – the common bed bug (*Cimex lectularius*) and the tropical bed bug (*Cimex hemipterus*). *C. lectularius* is generally distributed in the temperate and subtropical regions, while *C. hemipterus* is found in the tropics. With modern building design and indoor climate control systems, the indoor environment is becoming progressively more uniform worldwide. There will inevitably be an increasing number of localities where both species will be found. For example, over the last five years, tropical bed bugs have been reported in different parts of Europe, including France, Italy, and Russia.

The detection and monitoring of bed bugs are one of the most important aspects of integrated pest management (IPM) against this insect (Wang and Cooper 2011). Most monitors in the market today are pitfall traps, originally developed and tested against the common bed bug, *C. lectularius*. It is often assumed that these monitors, should they work well against *C. lectularius*, also would have similar efficacy against the tropical bed bug, *C. hemipterus*. These monitors relied on the smooth inner wall surface to contain the trapped bed bugs from escaping. However, if the trapped bugs can climb through these smooth surfaces and escape, this will compromise the monitoring efforts made by the pest management professionals. In a routine sponsored research investigation, it was observed that adult *C. hemipterus* could escape from a new pitfall trap, which otherwise effectively contained *C. lectularius*. This raised an important question: Are all pitfall traps that are effective in containing *C. lectularius* also effective against *C. hemipterus*? If differences are found, this would have profound implications for monitoring the latter species and the potential use of barriers against *C. hemipterus*.

Kim et al. (2017) evaluated the climbing abilities of two bed bug species, *C. lectularius,* and *C. hemipterus*, by examining their escape rates from smooth surface pitfall traps using four commercial bed bug monitors (Verifi Bed Bug Detector, ClimbUp Insect Interceptor, BlackOut Bed Bug Detector, and SenSci Volcano Bed Bug Detector). All detectors were used in the absence of lures or attractants. Unlike *C. lectularius*, adult *C. hemipterus* were able to escape from all traps. However, no or a low number of nymphs of both species escaped, depending on the evaluated traps. Investigation of the vertical friction force of adults of both species revealed a greater vertical friction force in *C. hemipterus* than in *C. lectularius*. Scanning electron microscope micrograph observation showed more tenent hairs on the tibial pad (fossula spongiosa) of adult *C. hemipterus* than on *C. lectularius*. No tibial pad was found on both species' fourth and fifth instars. Further histological examination revealed that the tenent hairs are hollow with an internal diameter of around 1 mm and penetrate the cuticular plate that forms the base of the tibial pad. The central space of tenent hair is continuous with the subcuticular space of the glandular epithelium, suggesting that a glandular secretion can be released through the hairs.

Bed bugs demonstrate traumatic mating/ insemination behavior. Despite vagina opening being present in females, it is not used in copulation. Male bed bugs pierce the female abdomen to inject sperm using their sharp genitalia during mating. Females have unique paragenital organs (the spermalege and associated structures) to receive traumatically injected ejaculates. Similar duplication sometimes occurs in *C. hemipterus* and *C. lectularius*, in which females typically develop a single spermalege on the right side of the abdomen. In a field bed bug collection, we found that about 3% of 185 adult females had a pair of spermalege. We tested the hypothesis using these D-females to examine if both duplicated spermaleges are functionally competent. Scars on female abdominal exoskeletons suggested frequent misdirected piercing of male genitalia. Close examination of the piercing sites on females revealed a biased distribution towards the right side of the body. A mating experiment showed that females remained unfertilized when the normal insemination site (the right-side spermalege) was artificially covered. This was true even when females had spermalege on both sides (D-females). This could be due to the handedness in male mating behavior. Irrespective of the observed disuse of the left-side spermalege, there were no differences between the right-side and left-side spermaleges based on histological examination.

Further investigation of an artificial insemination experiment confirmed that spermatozoa injected into the left-side spermalege generally migrated to the female reproductive organs, indicating an evolutionary potential for functionally competent duplicated spermaleges. In this study, we did not detect a function for the spermaleges located on the left side of the female abdomen. However, if D- females represent merely malformations, the observed frequency seems much higher than that of malformations of other laterally asymmetrical structures observed in other animals (Kamimura et al. 2014).

Over the past two decades, the worldwide resurgence of both common and tropical bed bugs has been mainly due to insecticide resistance. To date, bed bugs have been reported to become resistant to all the major classes of insecticides. The mechanisms involved include penetration resistance, metabolic resistance (cytochrome P450, esterase, glutathione S-transferase, and ABC transporters, target-site resistance (*kdr* and altered acetylcholinesterase), and behavioral resistance (Dang et al. 2017)

Pyrethroid resistance due to *kdr* (point mutations in voltage-sensitive sodium channels) in both *C. lectularius* and *C. hemipterus* has been reported worldwide. In *C. lectularius*, point mutations V419L, L925I, and I936F have been detected (Akhoundi et al. 2021), while M918I, L1014F, and D953G are common in *C. hemipterus* (Dang et al. 2021). A recent study by Lewis et al. (2022) revealed the distinct changes in *kdr* haplotype frequencies in US *C. lectularius* populations from 2007 to 2019, indicating that continued use of pyrethroids led to the loss of haplotype A (wild type) and increasing frequencies of haplotype C (L925I and V419L).

The strategies used in resistance management against bed bugs are to prevent or delay insecticide resistance development. It is essential to prevent and decrease any single mode of action used to achieve this. There are many chemical control formulations for bed bug control. They include liquid spray, pressurized aerosol, dust, fumigants, insecticide-impregnated fabric, repellent, and total release foggers. Many contain pyrethroids and are ineffective against pyrethroid-resistant bed bugs (Leong et al. 2022).

Insecticide rotation is a resistance management strategy that rotates insecticides of a different mode of action in sequence (e.g., once every quarter). However, with extensive pyrethroid resistance now, there are limited options available for rotation. Another resistance management strategy is to use an insecticide mixture. This single insecticide formulation contains two or more toxicants of different modes of action (e.g., pyrethroid + neonicotinoid). However, bed bugs have recently been resistant to mixture formulations (Dang et al. 2022). Other control approaches against resistant bed bugs include using entomopathogenic fungi, botanical insecticides, fumigants), heat treatment, physical removal using vacuuming, and inorganic and mineral compounds such as diatomaceous earth or silica gel.

Some modern approaches that are presently being investigated are (1) RNA interference (*RNAi*) which silences vital genes (e.g., genes that regulate molting, sperm release, larval development, reproduction, and locomotor activity) in insects, and (2) bed bug bait which incorporates phagostimulant such as ATP with a toxicant, (3) systemic approaches which use antiparasitic drugs (ivermectin, moxidectin) at human therapeutic doses, and (4) antibiotics to kill bed bug symbionts. Approval for their systemic usage in humans against bed bugs could be ethically challenging.

The biggest challenge for all these methods is developing a feasible, low-cost, low-maintenance, oral delivery system for bed bugs. Low-income housing probably remains the reservoir for bed bug infestation. The tenants are the poor who do not have the financial means to pay for the treatment and will gladly accept whatever little help they could get from their management. In most situations (when the control of bed bugs is not effectively carried out), the infestation in low-income houses will become massive and serve as an insecticide-resistant bed bug reservoir for spreading throughout the community.

Future research directions: Resistance to pyrethroids has been documented in both *C. lectularius* and *C. hemipterus*. Interestingly both species have independently evolved similar forms of resistance (*kdr* and metabolic). Why would both bed bug species that had diminished in importance in the 1960s become prominent again in the late 1990s, with populations of both species worldwide showing widespread pyrethroid resistance? Could all these modern pyrethroid-resistant populations have originated from locations where both species existed sympatrically? Could this be Africa, where the ancestors of the modern bed bugs (that live sympatrically) were initially subjected to selection pressure to DDT and later with pyrethroids due to indoor residual sprays and pyrethroid-impregnated bed nets – the “Out of Africa” hypothesis?

Recent discoveries showed that some plant essential oil synergize deltamethrin by inhibiting P450s activity in pyrethroid-resistant bed bugs warrants further investigations, especially in-field performance. Besides, research into the evolution of resistance mechanisms in field bed bug populations using different resistance management strategies such as rotation and mixtures could shed light on the feasibility of these strategies in the long term. Lastly, there should be more research on affordable non-chemical approaches, keeping in mind that poor communities are hit the hardest regarding bed bug infestations.

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DOCTORAL AWARD

Fipronil Insecticide Resistance in the Common Bed Bug and the German Cockroach

Maria A. Gonzales-Morales

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Research Statement

Indoor pests such as bed bugs and German cockroaches have serious health effects on humans. Bed bugs have piercing-sucking mouthparts that deliver salivary proteins to the host and can cause allergic and systemic reactions. Although evidence of disease transmission is lacking, bed bug bites can cause severe skin reactions including itching and secondary bacterial infections (1). A recent finding in our laboratory that bed bugs produce vast amounts of histamine in their feces raises concerns about their importance in triggering inhalant allergies and asthma (2). Cockroaches are a major cause of childhood asthma and transmit microbial disease (3). Presence of infestations in homes is linked to adverse psychological effects like insomnia and anxiety. Bed bugs and the German cockroaches are the most challenging pests to control, and pest management can be expensive and unaffordable to many.

My research aims to innovate with new pest management techniques and also improve cost to make bed bug and cockroach control sustainable, effective, and affordable. Research Plan. My motivation for conducting this research is five-fold: (a) I suspect there are labeled products used for other hematophagous insects that might work in bed bug control, (b) Bed bugs host range preference is broader than we expect; (c) Bait efficacy in German cockroach control can be improved by restructuring bait placement; (d) Insecticide resistance mechanisms in the common bed bug and the German cockroach need to be better understood to guide the development of new insecticides; and (e) This multi-disciplinary research plan integrates home-based studies, molecular biology, behavioral biology, veterinary medicine, and toxicology, which form an excellent landscape for my Ph.D. training and support my career goals. Broader Impacts, and Career Goals. My research findings will have global impacts by contributing to improving the quality of life in residential and hospitality settings, and particularly in disadvantaged communities. My research findings will contribute to the concept of ‘xenointoxication’—treating humans or animals to stem arthropod-vectored animal and human diseases—which holds broader promise for general vector control of malaria, leishmaniasis and arboviral diseases. My view as an entomologist goes beyond urban settings. I want to create bridges between urban entomology, medical entomology, and veterinary entomology to have a better understanding of how urban pests are affecting human and animal health. Overall, I want to improve the quality of life of low-income stakeholders; I want my scientific findings to benefit society. Research during my career will not only be focused on developing useful strategies to control major pests that will contribute to alleviate real problems, but I will be able to communicate this information to improve pest control strategies. Moreover, my ultimate goal is to become an urban entomology leader as an entomology professor. Being an educator is my calling. I am the first in my family to pursue a doctoral degree and the first woman to seek a science career, and I aspire to inspire and motivate underrepresented students and all minorities interested in urban entomology.

STUDENT PAPER COMPETITION

The Effects of Mattress Encasement Presence and Material Type on the Distribution of Bed Bugs (*Cimex lectularius*) and Bed Bug Control in Apartments

Shannon Sked, Changlu Wang, Rodrigo Ramos, Richard Cooper, Salehe Abbar, Xiaodan Pan and Sabita Ranabhat

Rutgers University – New Brunswick

Abstract

Among the tools utilized for bed bug, *Cimex lectularius*, management, the impact of encasements as a bed bug control tool has not been scientifically investigated. While vinyl encasements are an affordable option, their comparative effectiveness is unknown. We conducted laboratory and field research to evaluate the impact of encasements on bed bug distributions. Laboratory replicates were established using a mini mattress, box spring and frame with either vinyl, fabric or no encasements. Bed bugs were released during scotophase with a dry ice lure on the top of the bed complex. In these laboratory experiments, the proportion of bed bugs on box springs or the bed frames with either type of encasement was significantly lower than those lacking encasements. The proportion of bed bugs on mini mattresses with vinyl encasements was significantly lower than those with fabric encasement or without encasement. In a field experiment, 14 apartments were selected for vinyl, fabric or no encasements and subsequently treated using integrated pest management (IPM) tactics. Apartments were monitored every 2-4 weeks for 19 weeks after installing encasements. A lower proportion of bed bugs were found on the bed complex in apartments with encasements. No significant difference in the proportion of bed bugs found on the bed complex between vinyl and fabric encasement was found. There were no significant differences in the mean reduction of bed bug counts between apartments with vinyl, fabric, and no encasements at 83 ± 14, 88 ± 6, and 23 ± 73%, respectively. This preliminary investigation warrants further research evaluating distribution on a smaller scale (i.e., distribution on individual parts of the bed complex) with a larger sample size. Vinyl encasements remain a viable option in bed bug management programs in low-income communities as they assist in visual inspections and are much more affordable.

The Diversity and Abundance of Ectoparasites on House Mice (*Mus musculus*) Collected in New Jersey

Jin-Jia Yu and Changlu Wang

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Abstract

Commercial rodents are adapted to live in and around human dwellings and are found worldwide. They cause significant property damage and bring medical concerns to humans, including bites, allergy, disease transmission, and ectoparasites. Mites, lice, fleas, and ticks are common ectoparasites carried by house mice, which are also important vectors of zoonotic diseases for humans. Ectoparasites on rodents have been reported and identified in several countries. However, there are few studies documenting the diversity and abundance of house mouse ectoparasites in urban environments in the Northeastern United States. Lacking information about ectoparasite remains a huge knowledge gap for vector-borne disease prevention and rodent management. In this study, over 200 rodents were trapped using snap traps and live-traps at one residential community and one animal farm in New Jersey during 2021-2022. Most of the captured rodents were house mice, Mus musculus (Linnaeus, 1758), and only one was white-footed mouse, *Peromyscus leucopus* (Fischer, 1829). A total of 82.41% of examined rodents carried ectoparasites, in which only mites were found. Of all the examined mites, *Myocoptes musculinus* (Koch) was the most abundant species followed by *Ornithonyssus sylviarum* (Canestrini and Fanzago). Based on the results, the diversity of ectoparasites on urban-collected house mice may be low but the abundance of mites can be high.

Behavioral Interactions of Bed Bugs with Long-lasting Pyrethroid-treated Bed Nets

Christopher C. Hayes and Coby Schal

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Abstract

Malaria is vectored by *Anopheles* mosquitoes, and insecticide-treated nets (ITNs) are broadly used to interrupt its transmission. The uptake of, and adherence to, ITNs relies on perceived ancillary benefits, such as secondary pest control, including suppression of bed bug infestations. However, recurrent interactions of bed bugs with ITNs may

drive the evolution of pyrethroid resistance and interfere with malaria control. We have investigated the interactions of insecticide-susceptible (S) and pyrethroid-resistant (R) bed bugs with commonly used ITNs using two innovative behavioral assays that required bed bugs to pass through ITNs during host-seeking and aggregation-seeking, unfed and fully fed, respectively. We found no significant differences between the S and R strains in their ability to pass through permethrin-treated ITNs in the host-seeking assay, and significantly faster passage by S strain in the aggregation-seeking assay, with low mortality of 27% and 2%, respectively. However, significantly fewer unfed S and R bed bugs passed through deltamethrin-treated ITNs and blood-fed; with low mortality in the S strain (29%) and no mortality in the R strain. In the aggregation assay with deltamethrin-treated ITNs, only the S strain showed a significant decrease in aggregation, with high mortality (63.5%). These results demonstrate the marginal impact of pyrethroid-treated bed nets on bed bug host-seeking and aggregation behaviors. The low mortality suggests that ITNs would exert strong selection for the evolution of pyrethroid resistance in communities that adopted the extensive use of ITNs. These findings suggest that bed bug resistance has the potential to disrupt interventions to control malaria.

Biting Us and Taking Bites from Our Food?; Evaluation of ‘Xenointoxication’ Effects of Ectoparasite Drugs to Control Bed Bug Infestations in the Poultry Industry

Maria A. Gonzalez-Morales, Andrea E. Thomson, Olivia A., Rocio Crespo, Ronald Baynes, Ahmed Haija, Rick G. Santangelo, and Coby Schal

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Abstract

Bed bugs (Cimex lectularius L.) are obligatory hematophagous ectoparasites of humans but can feed on other warm-blooded vertebrates including rabbits, mice, and chickens. An increasing resurgence of severe bed bug infestations have been reported poultry houses. Controlling bed bug infestations in sensitive systems like poultry farms can challenging because there are no effective products labeled to control bed bug infestations in this environment. Various ectoparasitic products are available to control mites, fleas, and lice on various animals. We evaluated the on-host xenointoxication effects of ectoparasitic products, such as Ivermectin and Fluralaner on bed bugs with the main goal of providing a potential control method in infested poultry farms. Findings showed that bed bugs fed on chickens treated with fluralaner at a dose of 2.5mg/kg, resulted a 100% mortality.

Cockroach-associated *Wolbachia* Imitate the Pattern in their Bed Bug Host-prey

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Abstract

Cockroach management relies heavily on the use of conventional insecticides in urban settings. Yet the relationships between cockroaches and their endosymbionts, like *Wolbachia,* might also be exploited for control. Therefore, we screened 17 cockroach species belonging to three families (Ectobiidae, Blattidae, and Blaberidae) for the presence of *Wolbachia*. To map the evolution of *Wolbachia*-cockroach relationships, we combined bioinformatics approaches based on maximum likelihood phylogeny, phylogenetic placement, recombination events detection, and phylogenetic species clustering on a multi-loci sequence dataset (i.e., *coxA, hcpA, gatB, virD4,* and *wsp* genes) of *Wolbachia* genes. In addition, a comparative phylogenetic cospeciation analysis of biotin synthesis (i.e., biotin C and H) and *hcpA* genes of the F clade arthropod associated *Wolbachia* was performed in the context of host phylogeny. Only about 23.5% of the cockroach species screened harbor *Wolbachia*. Importantly, we confirm the previous report of *Wolbachia* in *Supella longipalpa* and detect the presence of Wolbachia, for the first time, in *Balta notulata*, *Pseudomops septentrionalis*, *Gromphadorhina portentosa*. All cockroach-associated *Wolbachia* herein detected were clustered monophyletically with the ancestor F clade *Wolbachia* of *Cimex lectularius*. The pairwise homoplasy index test detected significant recombination events throughout the *Wolbachia* strains. The result of event-based analysis on the concatenated biotin C and H from F clade showed a transfer event between cockroach-associated *Wolbachia* lineage and Cimicidae-associated *Wolbachia* with functional biotin. In toto, our results suggest two important hypotheses: (1) cockroach-associated *Wolbachia* might be acquired through predation on *Cimex spp.*, and (2) cockroach-associated *Wolbachia* have the complete biotin operon that provisions host with essential nutrients. Thus, we argue that *Wolbachia* may represent a suitable tool yet untapped for cockroach management.

Population Genetic Structure of the Common Bed Bug, *Cimex lectularius*, across the United States

Cari Lewis

University of Tulsa

Abstract

Despite a near global distribution, the population genetic structure of the common bed bug , *Cimex lectularius*, remains poorly understood. Beyond contiguous structures (e.g., multi-apartment building), the species relies on human-mediate dispersal; however, how this translates into the spread of propagules both within- and among-cities is largely unknown. Studies to date are limited by geographic scale, resulting in elusive inferences of how dispersal translates into genetic structure. Using high resolution genome-wide single nucleotide polymorphisms, we investigate patterns of population genetic structure at both city- and continental scales. At the continental level, we resolve previously unseen patterns of structure, indicating increased levels of within-city dispersal vs. among-city dispersal. Additionally, we find evidence of long-distance dispersal of propagules, potentially originating from regional source populations. Within cities, genetic structure does not appear to map to long-term human movements (i.e., along tracks of habitation). Instead, preliminary data support dispersal along commuter paths (e.g., rail lines and major highways). To our knowledge, these results represent the most comprehensive indication to date of the influence of human-mediated dispersal on patterns of genetic structure of the common bed bug within the United States and have implications for the future control of this species.

Evaluation of ActiveSense AIR Sensor Attached to Rodent Stations

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Abstract

Rodents are common pests in urban area, they cause significant damage to food and construction, and transmit diseases to humans or livestock. This study was designed to evaluate the effectiveness of ActiveSense AIR sensor for detecting rodent activity inside four types of rat bait stations and on three types of mouse bait stations, in crawl spaces from nine buildings of New Brunswick Housing Authority, NJ. The system would send

text and email alerts when there is an activity, and all alerts were serviced within 24 hours, with a thorough inspection of all rodent stations during one week period. The percentage of true alert, false alert, and missed alert cases from rat bait stations combined were 58, 28, and 14%, respectively (n = 320). And the percentage of true alert, false alert and missed alert cases from mouse bait stations combined were 58, 39, and 3%, respectively (n = 370). ActiveSense AIR sensor placed inside four types of rat bait stations detected 61–87% and 11–57% of the confirmed rodent activities before and after placing chocolate dollop, respectively. ActiveSense AIR sensors detected 88, 92 and 38% of the rodent activities when mounted on Aegis, Protecta and RTU mouse bait stations. Rodent baits are less preferred compared to peanut butter, sunflower seeds, or chocolate spread.

SUBMITTED PAPERS: BED BUGS

Metabolic and Target-site Insensitivity Confer Insecticide Resistance in Tropical Bed Bugs, *Cimex hemipterus*

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The common bed bug *Cimex lectularius* L. and tropical bed bug *C. hemipterus* (F.) are two major bed bug species globally. Both species have undergone a global resurgence over the last 25 years (Doggett et al. 2018). The resurgence is believed to be largely in part due to the development of insecticide resistance (Romero et al. 2007). Three main mechanisms have been identified for the development of insecticide resistance; target site insensitivity (e.g., *kdr* mutations), increased metabolic detoxification (e.g., cytochrome P450 monooxygenases [P450s], esterases, and glutathione S-transferases [GSTs]), and penetration resistance (e.g., cuticular thickening and additional protein deposition in the cuticle) (Dang et al. 2017a). Most investigations on insecticide resistance mechanisms on bed bugs concentrated on *C. lectularius*. The underlying resistance mechanisms in *C. hemipterus* remain limitedly explored. This study examined insecticide resistance and resistance mechanisms in several *C. hemipterus* populations from Malaysia and Australia.

Five *C. hemipterus* populations were used in this study, namely QLD-AU (collected in Queensland, Australia, in 2007), KL-MY (collected in Kuala Lumpur, Malaysia in 2005), CH-MY (collected in Penang, Malaysia in 2015), GL-MY (collected in Penang, Malaysia in 2015) and TT-MY (collected in Penang, Malaysia in 2015). A *C. lectularius* insecticide-susceptible strain (Monheim) was used for comparison since a susceptible *C. hemipterus* strain was not readily available.

To detect insecticide resistance, discriminating doses of deltamethrin (191 mg A.I. m^{-2}), DDT (2%), and malathion (5%) were tested on the bed bugs using the surface contact method (Dang et al. 2017b, 2021). In the synergism assays, each bed bug was pre-treated topically with 1 µl solution of piperonyl butoxide [PBO] (50 µg/µl), *S,S,S*-tributyl phosphorotrithioate [DEF] (15 µg/µl), or diethyl maleate [DEM] (50 µg/µl) dissolved in acetone, 2 h before insecticide exposure (Dang et al. 2021). Knockdown was recorded at intervals of up to 72 h (deltamethrin and malathion) and 120 h (DDT). Mortality was recorded daily up to 120 h. Three replicates of ten mixed adult bed bugs were done for each insecticide and strain in each experiment.

Individual DNA of the TT-MY (n=7), CH-MY(n=5), and GL-MY(n=5) strains was extracted, purified, and analyzed for *kdr*-related genes by PCR amplification, based on procedures described in Dang et al. (2015) and Soh and Veera Singham (2021). From the bioassays, some insects of TT-MY strain were knocked down within 60 min after deltamethrin exposure, while subsequent knockdowns were >12 h. We collected these insects and examined their *kdr*-mutations.

Results demonstrated that all *C. hemipterus* strains possessed high resistance to DDT and the pyrethroids and moderate to high resistance to malathion. Synergism studies showed that deltamethrin resistance in all strains was significantly ($P < 0.05$) inhibited by PBO, suggesting the involvement of cytochrome P450 monooxygenase in pyrethroid resistance. In contrast, deltamethrin resistance was not affected in DEF or DEM. Similar findings were found with lambda-cyhalothrin resistance. Malathion resistance was significantly ($P < 0.05$) reduced by DEF in all strains, indicating the involvement of elevated esterases. Resistance to DDT was not affected by DEM in all strains (Table 1).

Multiple *kdr* mutations (M918I, D953G, and L1014F) were detected by molecular analyses (Table 1). TT-MY strain was found with individuals possessing three *kdr* mutation combinations; D953G + L1014F (homozygous susceptible: M918), M918I + D953G + L1014F (heterozygous resistant: I918), and M918I + D953G + L1014F (homozygous resistant: I918). Individuals with M918I + D953G + L1014F (homozygous resistant: I918) survived longer on deltamethrin (>12 h) than those (≤1 h) with other combinations. Both M918I and L1014F mutations conferred DDT and pyrethroid resistance in *C. hemipterus*. When both mutations are present, it demonstrates the super-*kdr* characteristic in *C. hemipterus,* which prolonged the knockdown time of the test insects (enhanced DDT/pyrethroid resistance). We could not rule out the involvement of other mechanisms, such as penetration resistance.

Table 1. Metabolic resistance and *kdr* mutations identified in this study

Strain	Metabolic resistance			*kdr*		
	P450	Esterases	GST	M918I	L1014F	D953G
QLD-AU	X	X	X	X	X	
KL-MY	X	X			X	
TT-MY	X	X		X	X	X
CH-MY	X	X		X	X	X
GL-MY	X	X		X	X	X

In summary, the present study showed that both P450s and esterases were involved in metabolic resistance and played significant but varied roles in *C. hemipterus* resistance between different strains. M918I+L1014F mutations confer *super-kdr* characteristics against deltamethrin and DDT in *C. hemipterus*.

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Evaluation the Effectiveness of Various Bed Bug Monitors Based on Design

Souvic Sarker, Yuzhong Li, and Changlu Wang

Rutgers University – New Brunswick

Abstract

Bed bugs (*Cimex lectularius* L.) are challenging to find due to their nocturnal and secretive nature. Many commercial bed bug monitors are available to detect bed bugs. But very few studies have been conducted to evaluate the efficacy of bed bug monitors. This study focused on examining the effectiveness of various commercial bed bug monitors available in the market: Climbup Interceptors (large and small), Bed bug Coaster (Beap. Co), Blackout, and ActivVolcano (SenSci), Nattaro, and 1st Defense (round and square). Results showed that the number of bed bugs captured on Climbup HD (small) interceptors (small) was 4.0 times higher than ActivVolcano (SenSci) after 24 h. In addition, the number of captured bed bugs in Climbup interceptors (large) was 3.0 and 2.9 times higher than 1st Defense (square) and Bed Bug Detector Coaster, respectively. In a dual test assay, Climbup (large) caught 5 times more bed bugs than Blackout. However, in our other study on detecting bed bugs' escaping behaviors from monitors, the escaping number of missed stages of bed bugs from Climbup interceptors (large) was higher than Blackout. These findings suggest that, while Climbup interceptors are more effective than other monitors at capturing bed bugs, the number of escaped bed bugs is also higher in Climbup interceptors.

SUBMITTED PAPERS: OUTREACH AND EDUCATION

Understanding Your Audience to Successfully Apply Outreach Methods

Carrie B. Cottone, Astacia S. Carter, and Claudia Riegel

City of New Orleans Mosquito, Termite and Rodent Control Board

Abstract

The goal of an outreach program is to both educate the public as well as inciting behavioral changes that can prevent and mitigate pest problems at a household level. Public education and outreach is an important part of integrated pest management, but can also be one of the most difficult strategies to execute. Examples of outreach

strategies can include door-to-door community outreach, use of direct mail and door hangers, hosting in-person events, and even the use of social media to disseminate information. Before creating an outreach plan, it is important to understand your target audience. Conducting surveys of residents is an effective data-based method to assess people's knowledge about pests and control methods, thus allowing you to better target your audience.

Synchronous (Webinars) and Asynchronous (On-Demand) Computer-Based CEU Programs for Pest Management and Green Industry Professionals: A 10-Year Summary

Daniel Suiter[1], Rich Braman[2], Beth Horne[2], Kimberly Allen[2], Shimat Joseph[1] and Bodie Pennisi[3]

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Since 2013 the Department of Entomology's Griffin Campus Urban Pest Management program, in conjunction with the University of Georgia's Center for Urban Agriculture, has offered CEU-granting webinars to employees (pest management professionals [PMPs]) in the Structural Pest Control industry (Tables 1 and 2). The Georgia Department of Agriculture (GDA), the regulatory body of the pest control industry and commercial & private pesticide applicators, does not limit the number of CEUs that can be obtained by live, on-line events – i.e., webinars.

In 2017 we developed a second CEU-granting webinar series for pesticide applicators in Georgia's Green industries (turf and ornamentals) (Table 2). Green industry webinars are recorded, posted at GTBOP.COM for free viewing (no password or login credentials required), and granted CEU credit by the GDA. To receive state-mandated credit, however, licensees must view the recordings at their local county extension office. County extension agents have found the archives useful for those licensees who contact their office in dire need of CEUs to avoid letting their license lapse. The GDA mandates that a single archive can only be viewed for credit once during a calendar year. When seeking credit, a county extension agent must be present to witness the archive's viewing by the licensee. In the presence of the agent the credit-seeking individual must sign in on the approved sign in sheet. The completed sign in sheet must then be scanned and emailed, by the county office, to the Center for Urban Agriculture. It is recommended that the agent and the licensee keep a copy of the sign in sheet for their records. After receipt of the sign in sheet the Center adds information to it and forwards it to the GDA. In addition to being used to acquire mandated CEUs, the archived recordings can be used as supplemental teaching materials in college courses, by county agents to supplement Master Gardener Extension Volunteer training, or as part of hybrid, face-to-face, multi-hour programs for commercial and private pesticide applicators in need of CEUs.

Speakers for both the Structural and Green industry webinar series are primarily Ph.D. holders employed by major research institutions in the U.S., Europe, and Asia, as follows: University of Georgia; Georgia Southern; Georgia Department of Public Health; University of Florida; University of California Extension, Santa Cruz; Florida Medical Entomology Laboratory; University of Tennessee; University of Kentucky; University of Minnesota; Texas A&M; Mississippi State; North Carolina State; Ohio State; Clemson; Purdue; Rutgers; Virginia Tech; Universiti Sains Malaysia; USDA-ARS; BAM Federal Institute, Berlin, Germany; RMC Consultants; Douglas Products; Orkin; Rentokil; Univar; Northwest Exterminators; Coleman Consulting; and Litchfield-Cavo Attorneys at Law.

The webinars are fee based. Structural webinars are $15 per person for up to 20 people, and $10 per person for 21 or more participants; Veterans of U.S. military service, those on active military duty, and any person with a dot gov or dot edu email address attend free of charge. Green industry webinars are $20 per person flat rate. All webinars provide two CEU credits. The webinar programs have generated enough income that we began a mini-grant program designed specifically to award Georgia County Extension Agents a total of $27,000 over two years (2020 and 2021) in small grants ($500 to $3,000 each) in support of programming that furthers the goals of the Center for Urban Agriculture.

Webinars for the Structural Pest Control industry are held monthly, while Green industry webinars are held every other month beginning in January (Table 2). Speaker and topic lineup as well as CEUs awarded, for all states, are established in the fall for the upcoming calendar year. This allows individuals and companies to plan their webinar attendance well in advance based on their CEU and training needs. Listservs of both Structural and Green industry licensees (thousands of contacts in each list) are maintained in Mailchimp. One and two weeks prior to each Structural webinar the Center sends an Eventbrite announcement, including a link to register, to the appropriate Mailchimp list. Green industry announcements are sent one and six weeks prior to each webinar. County Extension agents also receive the Green industry announcement and are provided instructions on how to bypass payment. Because Green industry webinar content is known by January 1, county agents have all the information they need to build their own programming involving the Green industry webinars. Agents are encouraged to host webinar viewings at their county office for Green industry licensees and add additional programming, if desired, around the Green industry webinars. Agents are encouraged to charge a nominal fee for this service, and are allowed to keep all fees collected. The Green webinars are recorded, archived at GTBOP.COM, and can be used by county agents, among others, thereafter (discussed previously).

Webinars for PMPs have provided, or still provide, CEUs in GA, FL, AL, TN, NC, SC, NJ, MD, PA, NJ, Afghanistan (an operator licensed in AL and stationed in Kandahar, Afghanistan viewed the webinars to keep his AL license current), Nova Scotia, British Columbia, and Labrador/Newfoundland. Attendees of Green industry webinars are primarily from GA, as it is the only state for which credit has been pursued. Non-credit-seeking attendees have come from, at least, EPA, CDC, state regulatory agencies, TX, CO, CA, NY, ND, HI, IL, RI, Puerto Rico, India, and Mexico.

Participants for any webinar serving the Structural or Green industry are required to read the GDA Fraud Statement (on the sign in sheet), print and sign their name on the sign in sheet, and return the completed sheet to us within 2 to 3 business days following a webinar's conclusion. Group viewings are common. For every Structural webinar we have numerous companies sit down a majority to all of their licensed workforce (typically 3 up to 30 employees) to view a webinar. Each attendee will have been registered in Eventbrite and will have entered their license number. Those data are captured by Zoom in an Excel Attendance Roster and accessed by us, at zoom.us following each event, to confirm attendance for the entire two-hour period.

Products and Costs. Recent (Spring 2022) costs to maintain software and other licensing agreements and products was estimated at $10,300 per year, as follow:

- *Mailchimp*. $2,460/y ($205/month). Prices vary and are based on the number of records managed. Mailchimp is used to maintain email listservs for both Structural and Green industries; we also maintain a smaller list of attendees (for the Structural webinars) who are allowed to attend free of charge (Veterans, active duty military, dot gov, and dot edu email addresses).
- *Zoom Webinar*. Zoom Webinar is the platform we use to deliver the webinars. Since 2020, speakers tend to be widely knowledgeable of Zoom and rarely need a tutorial on how to use it. Attendees find it easy to navigate as well. Prior to Zoom we used Collaborate and GoToWebinar and found that they did not meet our needs. Zoom captures a registrant's Join Time, Leave Time, and Total Time in Session. These data are available after the webinar at zoom.us. State regulatory agencies require that these times be reported. Zoom keeps the event's recording for just 7 days, so if there's a need to save a recording it must be done within this period. Our current Zoom license is $1,400/y (1,000 connections) (June 2021 price); 2022 pricing for 1,000 connections is $3,400, but only $690 for 500 connections. In 10 years and more than 100 webinars delivered, we have never exceeded 500 connections.
- *Eventbrite*: Eventbrite is used to craft the webinar announcement, provide registration details, and allow people to register and pay. It's flexible in that it allows us to custom design the registration form and capture detailed data, such as an employee's name, license number, email, and company name when they register. Eventbrite charges roughly 17% of an event's ticket sales. In 2021, for instance, we sold $31,980 in webinar ticket sales. Eventbrite's user fee was roughly 17%, or $5,437. Several weeks after each event Eventbrite mails us a check minus their 17% fee. Eventbrite is our single greatest cost.

- *Zapier*: $908/y (2021). Like Mailchimp, the cost of Zapier is based on use. Zapier is a software product that is commonly described as the “glue” that allows Eventbrite and Zoom to communicate. When an individual receives our Eventbrite announcement they may register and pay. Moments after registration they receive an email from Eventbrite confirming registration. Following this, Zoom sends the registrant their unique link that they use to access the webinar on the day of the event. This email is sent to them one day and one hour before the webinar begins. This step, however, requires action on the part of our IT personnel. For participants to get their link, someone must act to trigger the sending of the links. This is the only downside to this process.
- *Telestream*: $99/y (2021). Telestream is a software package that allows the multiple cameras we use to talk to one another.

Webinar Program Highlights:

- 2013 to May 11, 2022: 105 CEU-granting webinars presented (Tables 1 and 2).
- From January 2017 to May 11, 2022, 83 two-hour webinars (51 Structural and 32 Green) were attended by 14,542 licensed professionals (84% PMPs) who acquired 30,400 CEUs (85% PMPs) and paid $150,622 in registration fees (82% PMPs) (Table 2).
- Webinar Attendance (January 2017 through May 11, 2022 – 83 webinars) (Table 2)
  - ✓ STRUCTURAL Webinars (n = 51): Almost half of the Structural webinars were attended by 200 to 299 participants, while 78% were attended by 100 to 299. Nearly one in five were attended by 300 or more.
    a. 0-99 attendees: 4%
    b. 100-199 attendees: 29%
    c. 200-299 attendees: 49%
    d. 300-399 attendees: 8%
    e. 400-499 attendees: 8%
    f. 500-599 attendees: 2% (one webinar was attended by 572 participants)
  - ✓ GREEN Webinars (n = 32): Four of five Green industry webinars were attended by less than 99 participants.
    a. 0-99 attendees: 81%
    b. 100-199 attendees: 19%
    c. >200 attendees: 0%

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Table 1. Structural Pest Control industry webinar data (2013 to 2016).

Year	Webinars	Industry Served	CEUs In...	Viewers
2013	4 @ 1 h	Structural	GA	117 (23-43)
2014	3 @ 1 h 3 @ 2 h	Structural Structural	GA, AL, SC, NC, TN, FL	439 (51-136)
2015	6 @ 2 h	Structural	GA, AL, SC, NC, TN, FL, NJ, Canada	377 (42-91)
2016	6 @ 2 h	Structural	GA, AL, SC, NC, TN, NJ, Canada	1,343 (103-395)
Total	**22**			**2,276**

Table 2. Structural and Green industry webinar data (January 2017 to May 11, 2022). In 2020 (pandemic year), part of the 22 total webinars included two free Emergency COVID webinars for PMPs (877 attendees, 2,631 CEUs); 2 Virtual Termite Workshop webinars (439 attendees, 1,317 CEUs); and 1 Urban Pollinator Protection webinar (70 attendees, 140 CEUs).

Year	Webinars	Industry Served	CEUs Awarded	Viewers	Income Generated
2017	6 @ 2 h 6 @ 2 h	Structural Green	4,232 1,494	2,116 747	$15,720 $3,968
2018	6 @ 2 h	Green	792	396	$3,050
2019	12 @ 2 h 6 @ 2 h	Structural Green	4,044 642	2,022 321	$23,775 $5,100
2020	16 @ 2-3 h 6 @ 2 h	Structural Green	10,210 904	4,447 452	$44,191 $7,705
2021	12 @ 2h 6 @ 2 h	Structural Green	4,826 656	2,413 328	$26,340 $5,640
2022 (May 11)	5: Jan to May 2: Jan, March	Structural Green	2,434 166	1,217 83	$13,913 $1,220
Totals	**83**		**30,400**	**14,542**	**$150,622**

SYMPOSIUM: IMPROVING INTEGRATED PEST MANAGEMENT STRATEGIES IN LOW-INCOME HOUSING COMMUNITIES

IPM in Multi-Family Housing – Issues in Implementation

J. Kofi Berko

US HUD

The Benefits of Using Assessment-based Pest Management (APM) for German Cockroach Control in Public Housing Units

Dini M. Miller and Eric P. Smith

Virginia Tech University

Abstract

Over the last several decades, low-income public housing facilities have been known to be infested with particularly large German cockroach populations. These populations persist even though the housing pest control contracts often require, and pay for, IPM practices to be used in their facilities. When Virginia Tech researchers began reviewing public housing contracts in Virginia and North Carolina, it was easy to see why these 'IPM programs' were not successful. Many of these 'low-bidder' contracts do not allow the technician enough time in each apartment to assess the size of the pest population. In addition, these pest management contracts did not require German cockroach population monitoring, even though all IPM programs are based on assessments of the pest population. There was a clear need for an effective, easy to apply cockroach management program in U.S. public housing authorities. This study determined the long-term efficacy of an Assessment-based Pest Management (APM) program for German cockroach control in U.S. public housing facilities. Specifically, we evaluated an APM program where the residents were not asked to clean or prepare for treatment, and where overnight cockroach trap counts were used to determine the volume of gel bait that would be applied. The APM baiting program was conducted for 15 mo in three housing authorities. In all three housing authorities, cockroach populations in test units were typically reduced by >90%. German cockroach infestations were even eliminated from 49 of the 65 (75%) test units during this study.

Let's Beat The Bug Completely! Improving IPM in Public Housing Using a Top-down/Bottom-up Approach

Stephen Kells

University of Minnesota

Factors Associated with the Prevalence of Pest Infestations in Low-income Communities

Changlu Wang

Rutgers University

Do-It-Yourself Pest Control in Affordable Housing

Zachary DeVries

University of Kentucky

Using Building-wide Quick Inspections to Identify Successful Bed Bug Management Strategies

Karen Vail

University of Tennessee

Overcoming IPM Obstacles: What's Working in Affordable Housing?

Susannah Reese

Northeastern IPM Center

SUBMITTED PAPERS: NEW PRODUCTS AND TECHNOLOGIES

Treatment of German Cockroaches in Large Voids with Advion Micro-Flow, a New Indoxacarb Bait Formulation

Alvaro Romero

New Mexico State University

Abstract

The German Cockroach, *Blatella germanica*, is one of the most common pest cockroach species found in the USA and other parts of the world. Infestations of this cockroach have been traditionally controlled with liquid insecticide sprays but in the last years, baits have gained popularity because their efficacy and low impact on human health and the environment. This presentation shows data from the application of Advion Micro-Flow, a new indoxacarb bait formulation, in large voids against German cockroaches.

Efficacy of Syngenta MicroFlow Bait on Cockroaches and Ants

Robert Puckett

Texas A&M University, AgriLife Extension Service

Abstract

Within the pest management industry, there is current momentum toward the development of dry flowable insecticidal bait formulations for the management of a variety of species of urban insect pests. Such baits allow users to apply them within wall voids and other harborage spaces where it is more difficult to apply conventional bait formulations. This presentation will detail the results of four laboratory experiments designed to determine the efficacy of Syngenta MicroFlow Bait (indoxacarb), as compared to that of Avert Flowable Cockroach Bait (abamectin) and untreated controls. Target pests in these trials included American cockroaches (*Periplaneta americana*), German cockroaches (*Blattella germanica*), tawny crazy ants (*Nylanderia fulva*), and rover ants (*Brachymyrmex patagonicus*). The mean mortality observed among German cockroaches, tawny crazy ants, and rover ants was significantly greater (and faster) when treated with Syngenta MicroFlow Bait, as compared to those treated with Avert Flowable Cockroach Bait. The mean mortality of American cockroaches treated with

Avert Flowable Cockroach Bait was equivalent to that of those treated with Syngenta MicroFlow Bait.

PLINAZOLIN® Technology, a Revolutionary New Chemistry to Manage Urban and Public Health Pests

Lisa Eppler, Mark Hoppé, Bob Cartwright

Syngenta Crop Protection

Abstract

Syngenta is excited to introduce a new active ingredient to manage urban pests. PLINAZOLIN® technology is a unique, proprietary isoxazoline insecticide working as an antagonist of the GABA receptor in the insect nervous system. It is non-repellent and works both by contact and feeding. With high potency and a slight delay in action, PLINAZOLIN® technology provides broad spectrum control of economically important pests. No cross-resistance has been observed to other known classes of chemistries till date.

We tested efficacy of PLINAZOLIN® technology against several urban pests including residual efficacy against mosquitoes on challenging surfaces. In our study we used *Anopheles gambiae* and *arabiensis* species. Plinazolin® when applied at 100 and 200 mg AI / m^2 on porous surfaces it achieved the minimum required WHO mortality of 80% and above at 72 hrs with residual activity up to six months. On key household and public health pests such as German cockroaches, Argentine ants, Pavement ants, Black carpenter ants, ticks, fleas, houseflies, and bed bugs etc. it provided excellent control when used at practical application rates.

Given its activity both via contact & ingestion, non-repellency, favorable toxicological profile, and good residual performance, PLINAZOLIN® technology has great potential to be used in urban pest management.

Scion Insecticide: A New Standard in Perimeter Pest Control

Brain Mount

FMC

Abstract

A look at new data surrounding the use of Scion Insecticide for perimeter pest control (Ticks, Mosquitoes) as well as Scion's ability to transfer from an exposed pest to a non-exposed pest.

Ridesco WG, a New Insecticide Wettable Granule, against Spotted Lantern Fly and Turf Pests

Jason Meyers

BASF

Abstract

Ridesco WG was applied on different surfaces and spotted lantern fly late instar nymphs and adults were exposed. Ridesco WG was applied to turf in the field, allowed to age naturally, then various turf pests were exposed to the treated turf over time. Mortality data are presented for each trial.

PT® Vedira™ Pressurized Spray: New Product, New Chemistry, New MOA

Joseph A. Argentine, Kenneth S. Brown, Kyle K. Jordan and Jason M. Meyers

BASF

Abstract

PT Vedira is an oil-based aerosol with the active ingredients alpha-cypermethrin and broflanilide, a unique dual mode of action combination. Broflanilide is the first member of IRAC Group 30, which act as GABA-gated chloride channel allosteric modulators. PT Vedira has demonstrated quick knockdown capability (10 to 24 seconds for 100% knockdown) and up to 84 days of residual activity (100% mortality) on tile and plywood

against a variety of household pests including cockroaches, flies, bed bugs and ants. PT Vedira has also shown excellent activity against resistant strains of these pests. PT Vedira has demonstrated non-repellancy in German cockroaches. There was no statistical difference in repellency between PT Vedira and untreated cockroaches, while other products containing pyrethroids were significantly more repellant than the untreated insects. Due to its novel mode of action and lack of cross-resistance, broflanilide can be considered an excellent rotation partner for all other insecticides and a powerful resistance management tool. Other products in the Vedira family containing broflanilide will be registered by BASF PS&S.

SYMPOSIUM: ASPECTS OF MYRMECOLOGY APPLICABLE TO INVASIVE ANT MANAGEMENT

Attempts at eradication and suppression of invasive ants often spark the development of new and/or refined control methods. This symposium will discuss how unique characteristics of several invasive ant species can influence the development and implementation of customized eradication/management tactics in the US and abroad.

Biology of a Recent Invasive, the Little Yellow Ant, *Plagiolepis alluaudi*

Matthew Miller[1], Andrea Lucky[2], Brian Bahder[1], and Thomas Chouvenc[1]

[1]University of Florida, FLREC, Davis, FL, [2]University of Florida, Gainesville

Development of a New Food Bait for Invasive European Fire Ants and Other Pest Ants

Asim Renyard, Claire Gooding, Jaime Chalissery, Jonathan Petrov, and Gerhard Gries

Simon Fraser University, BC, Canada

Development of an Improved Biodegradable Hydrogel Bait Delivery System to Attract and Manage Higher Numbers of Invasive Yellow Crazy Ants

Jia-Wei Tay

University of Hawaii at Manoa

Using Genetic Markers to Characterize Colonies of the Dark Rover Ant and Track their Fate after Bait Treatment

Edward Vargo[1], Pierre André Eyer[1], Phillip Shults[1], Alexander Blumenfeld[1], and Alexander Ko[2]

[1]Texas A&M University, [2]Bayer Environmental Sciences

Population Structure of Tawny Crazy Ants and Implications for Management

Ed LeBrun

University of Texas at Austin

Using Fire Ant Biology to Create a Pesticide-free Invasive Ant Management Program: Highly Effective Control of Fire Ants using only Hot Water to Protect Endangered Wildlife

Joshua King

University of Central Florida

The Role of Viruses in Invasive Ant Management

Chin-Cheng Scotty Yang[1], Chow-Yang Lee[2]

[1]Virginia Tech, [2]University of California, Riverside

Solenopsis invicta Females Overcome Inhibition of Sexual Development from the Colony Queen using Male Produced Tyramides

Robert K. Vander Meer[1], Satya P. Chinta[2], Erin E. O'Reilly[1], Tappey H. Jones[3], Rachelle M.M. Adams[4]

[1]USDA-ARS, [2]Foresight Science and Technology, [3]Virginia Military Institute, [4]Ohio State University

SYMPOSIUM: THE IMPORTANCE OF MONITORING IN IPM AND THE IMPLICATIONS

PART 1: MONITORING – WE ALL DO IT BUT ARE WE USING IT EFFECTIVELY?

Monitoring is an essential part of an IPM program. We train technicians to place the devices, check and clean the devices and to record their findings. It can provide information on what types of pests which can lead to targeted inspections and treatments. It can show areas of concern, increases or decreases in populations, and provide an "early warning system". While monitoring is used by most professionals, the data is often not collected and rarely used. Monitoring drives your entire program and can give you insights into where you need to focus. This symposium will look at how monitoring can make a pest management program more successful, how to use monitoring data, and the future of pest monitoring.

Monitoring for Mice in Multi-family Housing

Shannon Sked

Western Pest Services

Abstract

The house mouse, *Mus musculus domesticus*, creates significant public health risks for residents in low-income multifamily dwellings (MFDs). This study was designed to evaluate the spatial distribution of house mice in MFDs. Four low-income high-rise apartment buildings in three cities in New Jersey were selected for building-wide monitoring, two times with approximately one year be-tween the monitoring events. Presence of house mouse infestation was determined by placing mouse bait stations with three different non-toxic baits for a one-week period in all accessible units as well as common areas. Permutation tests were conducted to evaluate house mouse infestation spatial patterns. All four buildings analyzed exhibited a significant correlation between apartments with house mouse infestations and whether they share a common wall or ceiling/floor at both sampling periods except one building during the second inspection, which contained a high number of isolated apartments. Foraging ranges, speed of locomotion, and dispersal behavior of house mice are relatively larger, faster, and more common, respectively, compared to common urban arthropod pests. This could lead to the conclusion that house mice are as likely to infest non-neighboring apartments as those that share a wall or floor/ceiling. However, these results demonstrate that house mouse infestations tend to occur among apartments that share common walls or ceilings/floors. This spatial distribution pattern can be utilized in rodent management plans to im-prove the efficiency of house mouse management programs in MFDs.

Stored Product Pests, What do the Counts Mean for Treatments?

James Miller

Trece Inc.

Cockroach Counts and What to do about Them

Ron Harrison

Orkin International

Monitoring and Predictive Analytics for Arthropod Disease Vectors

Janet Kintz-Early

JAK Consulting Services

Bed Bug Detection and Monitoring Technology

Dini Miller

Virginia Tech

Abstract

Proactive monitoring is consistently being recommended as a method of rapid bed bug detection in multi-unit housing. The purpose of this study was to compare the cost and maintenance time required to implement either a passive or electronic bed bug monitoring system in multi-unit facilities. While the material costs of implementing a passive system was found to be more affordable than those of an electronic system, the maintenance time needed to check passive monitors (on a regular basis) greatly exceeded that of the electronic system. Overall, it was determined that although the electronic system implementation would require some technological advances before they could be widely used in apartment complexes, their efficiency for use in large multi-unit facilities would greatly exceed that of the passive monitoring systems, simply because they did not require regular (monthly) visual inspections.

PART 2: REMOTE PEST MONITORS AND MONITORING TECHNOLOGY

Remote monitoring is a relatively new technology to the pest management industry and has wide implications for how pest management professionals can service accounts. A quicker knowledge of pest issues can result in faster resolution. This symposium will look at many of the currently available remote monitoring systems, how to use them, and what it means to the industry.

Remote Pest Monitors and Monitoring Technology, and Overview

Bobby Corrigan

Corrigan Consulting

The use of Insect Remote Sensors for Food Safety Programs

Tom Mueller

Insects Limited, Inc.

The Bayer Remote Monitoring System (RMS) for House Mouse Detection in Commercial Facilities

Byron Reid

Bayer Research & Development Services

The use of Cameras for Rodent/Urban Pest Monitoring

Claudia Riegel, Timothy Madere, and Philip Smith

New Orleans Mosquito, Termite, and Rodent Control Board

Abstract

The daily lives of urban rodents have long been a mystery with glimpses that have been obtained either through observation for hours in dark, foul places or by random chance. The use of game cameras has revolutionized the way in which we observe urban rodent behaviors as well as the behaviors that we are able to observe. Pest management professionals can better understand the rodent movement and solve problem accounts. Game cameras have allowed for constant monitoring of pest activity, rodent speciation and proof of complete rodent infestation elimination. Game cameras have also changed the way rodent control products are tested for efficacy. Photographs taken by cameras can replace trapping which is more efficient and successful. Game cameras are a tool that can be used to peer into the cryptic world of urban rodents without hours spent sitting quietly in alleys, sewers, and attics.

ActiveSense® AIR Sensor for Rodent Detection

Joe DeMark and Mary Rushton

Corteva Agriscience

Abstract

The ActiveSense® system reliably monitors rodent activity 24/7. When a rodent triggers the systems AIR sensor, an alert is received and sent to the system hub, which immediately notifies with a text and/or email that activity has been detected. The ActiveSense system notifications will allow technicians to quickly pin-point trouble areas where inspections can be focused, promptly remove rodents, and reset traps in a timely manner for continued, uninterrupted control. ActiveSense AIR sensors can be installed in the most often-utilized rodent traps for both mice and rats including multi-catch traps (MCTs) with/without glue boards, slim-line MCTs, rat bait stations and via attachment to snap traps. ActiveSense can monitor virtually any site building, regardless of size or layout and city-wide areas for monitoring is also being tested. Rodent activity is documented, so you can learn exactly when and where activity occurs. Trials have been conducted from 2019 - 2021 at numerous locations across the US and Australia showing the expected results of the AIR sensor notifications to be overall > 90% accurate for the industry important traps/station types tested.

Blue Tooth Technology for Remote Rodent Monitoring Applications

Patrick Lynch

Bell Labs

Performance of ActiveSence® Insect Remote Monitoring System in Public-sector Housing

Mary Rushton1, Ameya Gondhalekar2, Joe DeMark1, and Neil Spomer1

1Corteva AgriScience, 2Purdue University

SYMPOSIUM: FIFTEEN YEARS OF PROFESSIONAL CREDENTIALING

ESA's Certification Program

Willet Hossfeld

ESA

NPMA's Accreditation Program

Allie Allen

NPMA

State Licensing

Allie Allen

NPMA

QualityPro Career Pathway Project and where Industry Credential Fit in a Career Pathway

Allie Allen

NPMA

How McCauley Services Uses Credentialing in Marketing, Recruitment, and Retention

Christian Wilcox

McCauley Services

How Rollins Uses Credentialing in Marketing, Recruitment, and Retention

Judy Black

Rollins, Inc.

SYMPOSIUM: PUBLIC HEALTH PESTS AND PEOPLE – EDUCATION AND LESSONS LEARNED

Investigating the Pathways of Rodenticide in Urban Wildlife as it Relates to Secondary Exposure

Niamh Quinn

University of California Cooperative Extension

L.A. Times or Medieval Times: L.A. Typhus Outbreak of 2019

Syliva J. Kenmuir

BASF

Pest Control and its Role in Public Health as it Pertains to Rodents

Claudia Riegel

New Orleans Mosquito, Termite, and Rodent Control Board

Western Gulf Center of Excellence for Vector Borne Diseases-Outreach Program and Updates on the Past Three Years of Work

Sonja Swiger

Texas A&M AgriLife Extension

Ticks and Pathogens in Dense Suburban Environments

Jody Gangloff-Kaufman

NYSIPM Program, AHDC, Cornell University

SYMPOSIUM: THE OUTER LIMITS: RESEARCH, IMPACTS AND MANAGEMENT OF PERI-DOMESTIC COCKROACHES IN URBAN ENVIRONMENTS

This symposium will provide current information on the importance of peri-domestic cockroaches. Presentations will be focused on biology, behavior and management tactics with emphasis on Turkestan, Asian, Smoky-brown, American and Oriental cockroaches.

The Turkestan Cockroach: A Common Peri-domestic Cockroach in the Southwestern United States

Alvaro Romero, Cassandra Garza, and John Agnew

New Mexico State University

Abstract

The Turkestan Cockroach (*Blatta lateralis)* is a peridomestic species that has become a notorious pest in the southwestern United States. Although Turkestan cockroaches regularly dwell in peridomestic areas, they invade human indoor areas through holes, cracks, and gaps between door and floors becoming a nuisance and public health concern due to their ability to mechanically vector pathogens. Infestations of this cockroach have been traditionally controlled with liquid insecticide sprays but in the last years, baits have gained popularity because their efficacy and low impact on human health and the environment. This presentation will provide information about the efficacy of fresh and aged bait formulations against this pest. Also, laboratory evaluations will show the secondary kill effect of baits as an additive value of some formulations. Finally, a review of the use of plant-derived essential oils as insecticides and repellents for Turkestan cockroaches will be presented.

Keep It Outside: IPM Tips, Tricks, and Solutions for Residential Peri-domestic Cockroach Control

Desiree Straubinger

Certus Pest, Inc.

Abstract

Cockroaches are a significant residential pest that can easily develop into large infestations before they are even discovered inside. The ideal is when a pest control professional identifies the population before they get inside a customer's home. Treating cockroaches outdoors where they prefer to live is easier than allowing them to gain access to the home where control becomes more difficult. The knowledge and implementation of solutions for common outdoor control opportunities can be the key to eliminating this pest before they entrench inside and become a larger problem for pest control professionals and their customers.

Challenging Situations in Commercial Peri-domestic Cockroach Control

Ashley Roden

Sprague Pest Solutions

Abstract

Sprague Pest Solutions is a pest management company headquartered in Tacoma, WA. We service commercial accounts in ten states on the west coast, ranging from Washington to Arizona. Traditionally, peridomestic roaches have been a minor pest in the commercial accounts we service, though when encountering peridomestic roaches, American cockroaches (*Periplaneta americana*) are seen with the most frequency. As it pertains to peridomestic roaches, recent trends include: 1. COVID-19 policies that sent many city workers home to work remotely led to a dramatic decrease in reports of peridomestic cockroaches. With the gradual return of workers to the urban core offices, we have seen increased reports of American roaches. 2. Reports of Turkestan roaches (*Shelfordella lateralis*) have increased in the last five years, and they have been found as far north as the Canadian border. One employee discovered a breeding population inside a food distribution facility in Washington State. Most of the captures outside of California and the American Southwest can be traced back to shipments arriving from

these areas to the Pacific Northwest. 3. More of our employees are reporting three-lined cockroaches (*Luridiblatta trivittata*) in exterior rodent bait stations in Northern California and Southern Oregon. In sum, we have seen changes in reporting of peridomestic roaches in commercial buildings over the last few years due to COVID-19 work trends and policies and have also tracked the increased spread of Turkestan/three lined cockroaches from the areas where they were initially reported.

The Pendulum Swing of Turkestan and Oriental Cockroach Populations in Arkansas over an Eight Year Observation

Christian Wilcox

McCauley Services

Abstract

Turkestan cockroaches (*Blatta lateralis*) in North America are considered a primarily exterior peri-domestic species of the Southwest region of the United States. This species has begun to be more commonly identified as a structural pest in the South Central and Southeastern United States. The population distribution of the Turkestan cockroach in Arkansas has been tracked over a eight year period noting a spike in the summer of 2019 and then a decline with an increase in Oriental Cockroach (*Blatta orientalis*) populations in 2020-2021.

Laboratory Evaluation of Insecticidal Baits for Outdoor Baiting for Peri-domestic Nuisance Cockroaches

Michael K. Rust[1], Dong-Hwan Choe[1], Joyce Ho Eun[1], and Andrew Sutherland[2]

[1]University of California, Riverside, [2] UCCE Alameda/UC IPM

Peri-domestic species of cockroaches are frequently encountered in and around structures within urban areas of California and the southwest. American cockroaches, *Periplaneta americana* (L.) are especially a problem in sewer systems. The oriental cockroach, *Blatta orientalis* L., has been the 2nd most prevalent species found around residential structures (Ebeling 1975). However, the introduction and recent spread of the invasive Turkestan cockroach, *Shelfordella lateralis* (Walker), has resulted in the replacement of the oriental cockroach throughout much of California (Kim and Rust 2013).

The objective of the study was to determine the activity of various commercial baits against the three primary outdoor cockroach species encountered in California.

Materials and Methods

Insects. American cockroaches were reared in 121-L garbage bins equipped with electrical barriers along the upper inner surface to prevent cockroaches from escaping. The oriental and Turkestan cockroaches were reared in 3.875-L glass jars. The jars were provisioned with corrugated cardboard for harborage, dog food (Purina Dog Chow, Nestlé Purina Petcare, St. Louis, MO), and water jars *ab libitum*. The colonies were maintained at 24 ± 2°C, 30–50% RH, and a 12-hour photoperiod.

The cockroaches were lightly gassed with CO_2 to collect the adults and mixed nymphs. Only adult females without oothecae were selected.

Test Arenas. Large plastic storage containers (58.4 by 41.3 by 31.4 cm) were used as test arenas. A rectangular piece of filter paper was taped to the bottom of each container to serve as a floor liner and provide cockroaches easy traction. A large cardboard container placed at one end of the arena served as a harborage. Two triangular notches along the rim of the cup permitted cockroaches access when the cups were inverted in the arena. A small amount of vasoline was lightly applied on the inner upper rim of the arenas as a thin 5-cm band to prevent the cockroaches from escaping. A water jar and a plastic weighing boat containing 6-10 pieces of dry dog food for the arenas were placed at the opposite end of the arena from the harborage. Food was replenished as needed.

Five adult males, 5 adult females, and 25 nymphs (mixed instars) were placed in each arena. The cockroaches were acclimated for 7 d before baits were introduced into the arenas. Any dead cockroaches were replaced with live cockroaches prior to baiting.

Commercial Baits. The baits tested included 0.05% abamectin B1 + 0.5% pyriproxyfen bait (**VEND**, Vendetta Plus, MGK, Minneapolis, MN), 1.0% clothianidin gel bait (**IMP**, MaxForce® Impact™ Roach Gel Bait, Bayer Environmental Sciences, Research Triangle Park, NC), 0.1% emamectin benzoate gel bait (**OPTI**, Optigard® cockroach gel bait, Syngenta Crop Protection, LLC, Greensboro, NC), 0.05% fipronil gel bait (**MAXM**, Maxforce® FC Magnum, Bayer Environmental Sciences), 0.6% indoxacarb gel baits (**ADV**, Advion® cockroach gel bait; **ADVE**, Advion® Evolution cockroach gel bait, Syngenta Crop Protection), and a 0.22% indoxacarb granule (**ADVG**, Advion® insect granule, Syngenta Crop Protection).

Test Protocol. Baits were provided in small plastic weigh boats. The bait was placed in the corner of the arena near the food dish and water jar. If > 90% of the bait was consumed at any time during the 14 days, another 0.5 or 1 g of fresh bait was placed in the boat. The number of dead cockroaches was counted at 1, 4, 7, and 14 d. Five replicates were tested for each commercial bait and cockroach species.

To determine the amount of bait consumed, it was necessary to compensate for the water loss from the baits. Five weigh boats (≈1 g of bait) were prepared for each bait and placed in an aquarium covered with a screen lid to prevent any access by insects. These baits served as evaporative controls to determine the amount of water loss during the study. The baits were weighed at 1, 4, 7, and 14 d.

The average water loss ratio (R_{wl}) was determined for each bait by the following equation: water loss ratio = (initial wt – final wt)/ initial wt. The consumption of bait (g) at day 1 and day 14 was determined by the following equation: Consumption = initial bait wt – [final bait wt * (Initial bait wt/Final bait wt)]. The difference between that estimate and the original amount placed in the weigh boat represents the reduction because of feeding.

Data Analyses.- The mortality data of adults and nymphs were combined and analyzed with a Kaplan-Meier test providing a survivorship function [S(t)]. Survival curves of cockroaches exposed to the commercial baits were compared with log rank test (SPSS 2020). The amount of water loss of the baits and the amount consumed were compared with an ANOVA and the means were separated by Tukey's HSD.

The number of dead cockroaches at day 14 was divided by the amount (g) of bait consumed, providing an estimate of the total number of cockroaches killed by 1 g of bait. An estimate of the number of cockroaches killed by an entire tube of gel bait (30 g) was calculated.

Results

Laboratory Efficacy Studies. The commercial baits consistently killed more adult male and female *P. americana*, *B. orientalis* and *S. lateralis* than nymphs. The greatest overall survival to the baits was observed with *S. lateralis*. Only ADV bait killed 100% of the adults within 14 days for all three species.

The survivorship functions for the various commercial baits against *P. americana* were significantly different (χ^2 = 580.1, df = 7, **P** < 0.001). The order of activity against mixed populations was as follows: MAXM > ADV = ADVE = ADVG = OPTI = IMP > VEND > UNT. None of the baits provided 100% mortality at day 14. The survivorship functions for the baits against *B. orientalis* were significantly different (χ^2 = 732.0, df = 7, **P** < 0.001). The order of activity against mixed populations was as follows: MAXM = OPTI > IMP > ADVG = ADVE ≥ ADV > VEND > UNT. The ADV, ADVG, and MAXM baits provided 100% kill of mixed populations by day 14. The survivorship functions for the commercial baits against *S. lateralis* were significantly different (χ^2 = 812.5, df = 6, P < 0.001). The order of activity against mixed populations was as follows: MAXM > ADVE

= ADV > ADVG > OPTI > VEND > UNT (Fig. 1). Only the ADVE baits provided 100% kill by day 14.

The gel baits lost about 33-49% of their weight within the first 24 hours. From day 1 to day 14, the gel baits lost an additional 3-5% of their weight due to water loss.

The ADV, ADVE, and OPTI baits typically had greater consumption than did MAXM and IMP (Table 1). The least amount of bait consumption consistently occurred with MAXM and IMP baits against all three species.

Discussion

Limited data exists on the efficacy of baits against the peridomestic species of cockroaches around structures (Nasirian and Salehzadeh 2019). The activity of the commercial baits tested can be categorized due to contact or consumption. Baits containing fipronil (MAXM) or clothianidin (IMP) tended to have greater contact activity than the baits containing indoxacarb (ADV, ADVE), emamectin benzoate (OPTI), or abamectin (VEND). This corroborates a study reporting that *P. americana* consumed considerably more indoxacarb bait than fipronil bait (Baker et al. 2012). The fipronil bait killing more cockroaches per gram than did the indoxacarb bait. The fipronil and clothianidin baits had greater contact activity than did the other baits. Greater numbers of cockroaches were killed per gram of fipronil or clothianidin bait applied than indoxacarb, abamectin and emamectin benzoate. Thus, greater consumption of the abamectin and emamectin benzoate baits will require additional bait applications to control heavy infestations.

Baits containing clothianidin, fipronil, and indoxacarb were effective in killing all three peri-domestic species. When treating large infestations, additional applications of the indoxacarb may be necessary.

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Figure 1. Survival curves of mixed populations of *S. lateralis* against commercial baits. Lines followed by the same letter are not significantly different (Log rank test, P = 0.05).

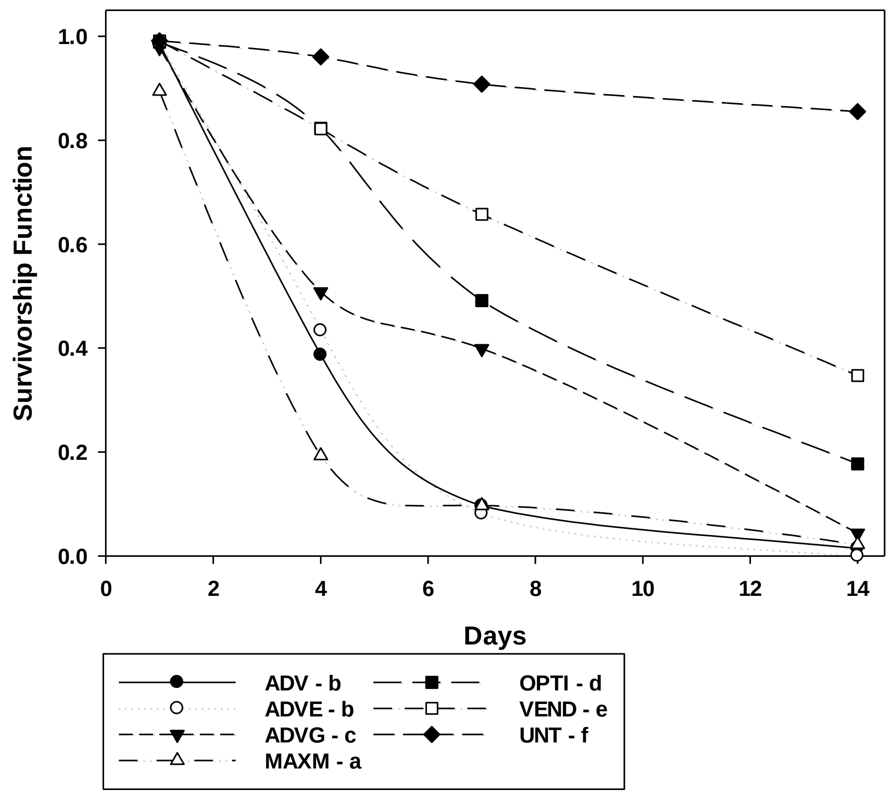

Table 1. Commercial bait consumption of mixed groups of *S. lateralis* and the estimated numbers of cockroaches killed per gram of bait.

Bait	Avg. (± SEM) Consumed at Day		No. Killed/ g bait	No. Killed/ bait tube
	Day 1	Day 14		
ADV	0.43 ± 0.037 a	0.52 ± 0.135 bc	240	14,423
ADVE	0.45 ± 0.084 a	1.26 ± 0.112 a	139	8,333
IMP	0.05 ± 0.020 b	0.11 ± 0.007 c	1,136	68,182
MAXM	0.07 ± 0.029 b	0.11 ± 0.034 c	290	17,423
OPTI	0.48 ± 0.112 a	0.57 ± 0.108 b	247	14,842
VEND	0.44 ± 0.087 a	0.44 ± 0.112 bc	220	13,227

[a] Means followed by the same letter are not significantly different (P< 0.05).

Outdoor Baiting Programs for Control of Turkestan Cockroaches in California

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[1]University of California Division of Agriculture and Natural Resources; Hayward, CA, [2]University of California Division of Agriculture and Natural Resources; Alhambra, CA,[3]Department of Entomology, University of California, Riverside, CA

Abstract

Insecticidal baits are proven effective tactics for domestic cockroach species, but limited information about their use and efficacy exist for outdoor applications targeting peridomestic species. We evaluated three commercial bait products against large populations of Turkestan cockroaches at two public school campuses in California over a one-year period. Baits were applied monthly around buildings and in hardscape elements within self-contained tamper-proof stations at product label rates. Populations were monitored using attractant sticky traps placed overnight once per month adjacent to structures in treatment areas. Populations plummeted at both sites after baiting in June, just prior to mating and ootheca deposition., with 90% fewer cockroaches trapped after one month. Cockroach density also declined significantly in untreated plots, however, suggesting that cockroaches moved from treated areas to untreated areas, producing secondary mortality via cannibalistic scavenging.

Key Words peridomestic cockroaches, insecticidal bait, foraging range

Introduction

Common pest control strategies for peridomestic cockroaches aim to exclude or repel them from buildings. Insecticide sprays, however, may not always be effective at keeping cockroaches out and have been identified as important surface water contaminants. Insecticide baits have been shown to be highly effective against domestic cockroaches indoors, even in the presence of competing food resources. Cannibalism and cannibalistic scavenging, well documented for many cockroach species, may confer secondary mortality after baiting. Few studies have evaluated the efficacy of outdoor baiting programs for peridomestic cockroaches. Increasingly, the most common peridomestic cockroach species in the American Southwest is *Shelfordella* (*Blatta*) *lateralis*, the Turkestan cockroach, an invasive species considered endemic to central and western Asia as well as northeastern Africa. Highly adapted to arid environments, they have displaced other peridomestic cockroach species in parts of their introduced range. In late 2016, we connected with several public school districts battling large populations of Turkestan cockroaches. Perimeter insecticide programs at the sites had failed to reduce populations, structures were being routinely invaded, and stakeholders were concerned about pesticide exposure and community health. We hypothesized that targeted applications of insecticide baits, together with improved monitoring programs and structural exclusion tactics, would provide control at these sensitive sites.

Materials and Methods

Two public school sites were included in this study: a high school in Mendocino County and an elementary school in Riverside County. Campuses were divided into large circular treatment areas (~ 30 m D, ~ 700 m^2, n = 24 in Mendocino, n = 20 in Riverside) which were then assigned to receive one of four treatments: indoxacarb gel bait (Advion Cockroach Gel Bait, 0.6% indoxacarb; Syngenta), clothianidin gel bait (Maxforce Impact Roach Gel Bait, 1.0% clothianidin; Bayer), indoxacarb granular bait (Advion Insect Granule, 0.22% indoxacarb; Syngenta), or no treatment at all (untreated control). All products were applied according to label guidelines; four times at the Mendocino site (once per month during June 2017 – September 2017) and twice (October 2017 and June 2018) at the Riverside site. Higher rates were used when monitoring indicated cockroach populations were high. Baits were applied in tamper-proof stations (Protecta RTU; Bell Laboratories, Inc.) or in plastic cylinders (DURA 1 in. x 1 in. PVC Slip x Slip Couplings; Home Depot, Inc.) within in-ground utility ports. In addition, both schools implemented exclusion strategies designed to eliminate breeding sites or prevent incursion into structures, including installation of sweeps on exterior doors and filling of gaps and voids in concrete and around doors and windows. Cockroach populations were assessed once monthly using attractant glue traps (LO-Profile Trap; B&G Equipment Co.) placed overnight (2100 h – 600 h) along exterior walls of structures (1 trap per treatment area). Nighttime surveys were conducted to assess localized population densities. Concurrently, school districts tracked complaints and maintained monitoring programs inside buildings. Using a completely randomized design, four treatments were replicated six times each at the Mendocino site and five times each at the Riverside site. Factors included treatment and observation month, and the response was the number of cockroaches trapped per month, a continuous numerical variable. Means comparisons of the response variable per month and per treatment were conducted using Wilcoxon signed rank tests and JMP Statistical Software.

Results

Initial monitoring indicated a much larger population in Mendocino (14.8 ± 2.9 cockroaches per glue trap, n = 23, June 2017) than in Riverside (1.95 ± 1.00 cockroaches per glue trap, n = 20, October 2017). Therefore, the maximum product rates were used in Mendocino (3 g per bait placement x 4 bait placements per treatment area = 12 g bait per treatment area) while lower label rates were used in Riverside (1 g per bait placement x 4 bait placements per treatment area = 4 g per treatment area).

Mendocino County: Within one month, the population plummeted (2.38 ± 0.64 cockroaches per glue trap, n = 24, July 2017). This represented an 84% reduction (Figure 1a). Bait application rates were therefore reduced to the lower label rate (1 g per placement, 4 g total per treatment area) for the remainder of the study. A visit to the site in June 2018 indicated that *S. lateralis* populations were still present, albeit at much lower densities than originally measured (2.17 ± 0.72 cockroaches per glue trap, n = 23). Overall treatment differences could not be detected ($\chi^2 = 2.90$, P = 0.41) due to population crashes in untreated areas. No cockroaches were trapped in treated areas during September 2017, but small numbers (0.83 ± 0.40 per glue trap, n = 6) were detected in untreated areas; this was a significant treatment difference ($\chi^2 = 9.82$, P = 0.02). Site staff reported that complaints and indoor trap catches declined significantly during the study. Stakeholders in the community, including parents of schoolchildren and district officials, thanked the project team for the successful program.

Riverside County: The first baiting event took place in October 2017. Population densities in June 2018 were unchanged, however (1.75 ± 0.46 cockroaches per glue trap, n = 20), so another application was made. One month later, no cockroaches were trapped, but nighttime visual surveys indicated small populations still existed. In September 2018, trapping detected moderate densities in untreated areas (1.40 ± 0.68 cockroaches per glue trap, n = 5), but this treatment difference was not statistically significant ($\chi^2 = 7.53$, P = 0.057). At the end of the season, densities approached zero (0.05 ± 0.05 cockroaches per glue trap, n = 20; one cockroach was trapped within an untreated area), and a nighttime survey detected no cockroaches. Overall density declined by 97% between October 2017 and October 2018 (Figure 1b). Staff trapped few cockroaches within buildings and reported no complaints during the study period.

Discussion

Turkestan cockroach populations at both campuses declined dramatically during the intervention programs. The combination of outdoor bait applications and structural exclusion appeared to provide effective control. Peridomestic cockroaches may be especially vulnerable because individual lifespans are greater than one year, eggs (within ootheca) are deposited only during the summer, and there are few overlapping life stages. *S. lateralis* overwinters as nymphs of mixed age that hatched from ootheca deposited during summer months. Control programs targeting nymphs and young adults in late spring or early summer may prevent deposition of ootheca. Such targeted programs disrupt the pest life cycle and may eradicate localized populations. In this study, bait applications in June resulted in rapid and lasting reductions in cockroach density. Initial baiting conducted in October failed to reduce populations, perhaps because ootheca had already been deposited and many hatchling nymphs were able to avoid exposure to baits and successfully overwinter. Populations at our study sites were historically targeted with regular pyrethroid insecticide spray applications to building perimeters. Control failures may have been experienced because sprays killed some cockroaches foraging near structures but did not address harborage and breeding locations found throughout the campuses, ensuring steady pressure from replacement individuals. Furthermore, without the exclusion measures demonstrated, cockroaches were previously able to easily enter classrooms and other indoor spaces. We were unable to experimentally detect control efficacy of our bait treatments since populations declined significantly in untreated areas as well as treated areas. One explanation for this experimental failure is that our treatment areas were too small, allowing for movement of foraging cockroaches into untreated areas and out of baited areas. Size of our treatment areas (30 m D circles, ~ 700 m^2) was determined by considering previous work that estimated foraging distances of large peridomestic cockroaches. For instance, foraging ranges of *Periplaneta fuliginosa* have been estimated to be less than 300 m^2, and individual *Blatta orientalis* adults have been observed to move less than 10 m between sightings. Turkestan cockroaches, which are flightless and lack tarsal arolia, were expected to exhibit dispersal patterns like those observed for *B. orientalis*. It seems likely, however, that foraging ranges were much larger than treatment areas and that cockroaches consuming bait in treated areas died in untreated areas, exposing resident cockroaches there to secondary mortality during cannibalistic scavenging events. Cannibalistic scavenging was observed during nighttime surveys, and several insects observed on glue traps appear to have been partially consumed, perhaps by conspecifics. We conclude that outdoor baiting programs have the potential to drastically reduce Turkestan cockroach populations and control significant pest problems over large areas, especially when combined with structural exclusion practices. Such programs represent valuable alternatives to liquid insecticide sprays, which may contribute to environmental contamination issues, insecticide resistance development, and may be ineffective in many instances.

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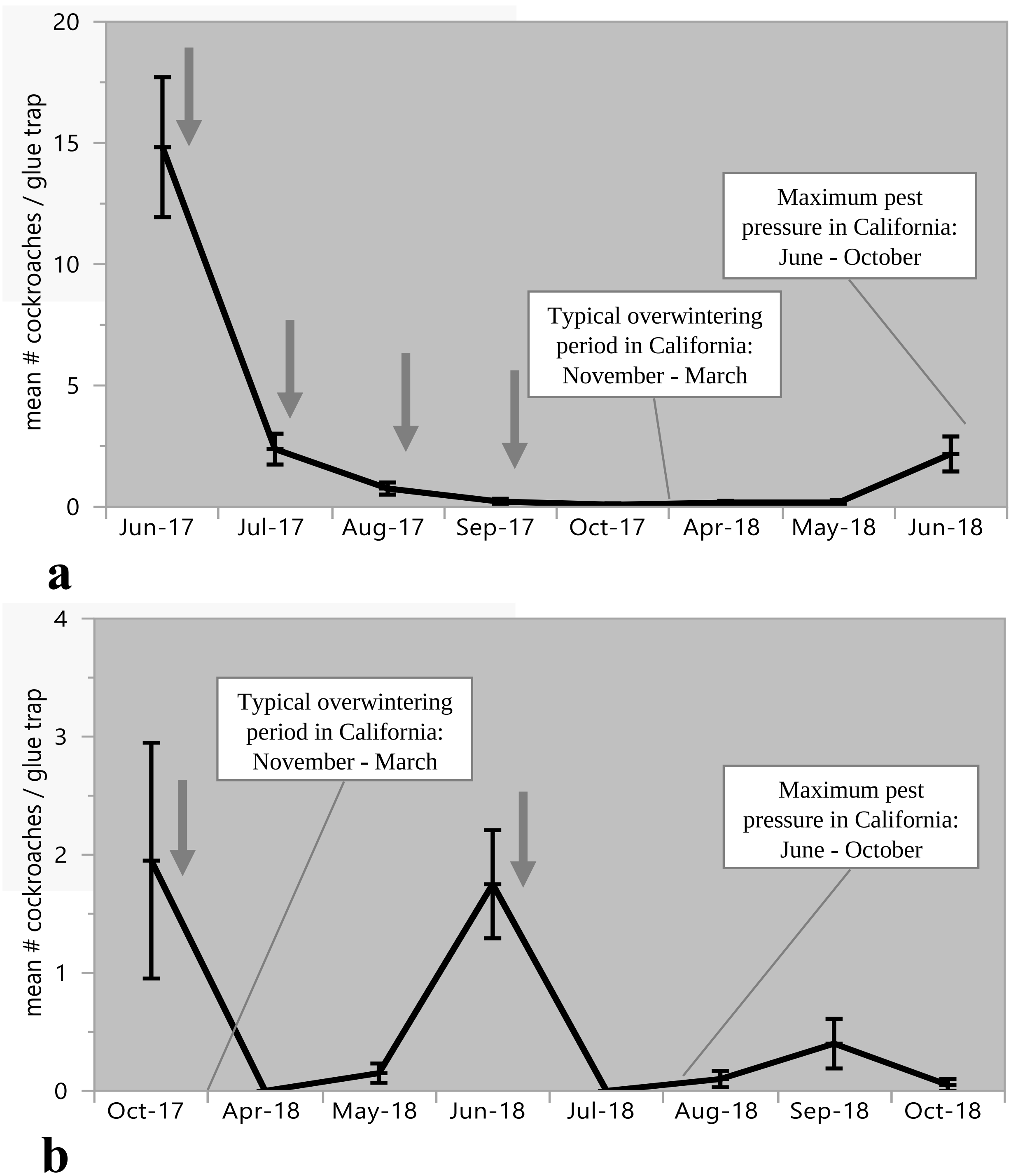
Figure 1. Population density of Turkestan cockroaches, *Shelfordella* (*Blatta*) *lateralis*, at **a)** a public high school in Mendocino County and **b)** a public elementary school in Riverside County during a one-year demonstration of an integrated pest management program that utilized targeted insecticidal bait applications and structural exclusion tactics. Vertical arrows indicate bait application dates. Call-out boxes indicate periods of expected high pest pressure or inactivity due to overwintering.



Efficacy of Liquid and Bait Insecticides against American Cockroaches (*Periplaneta americana*)

Ameya D. Gondhalekar

Purdue University

Abstract

American cockroaches (*Periplaneta americana*) are a globally important peridomestic cockroach pest species. In comparison to indoor pest cockroach species (e.g., German and brown-banded cockroaches), the control of American cockroaches, which mainly reside in the near vicinity of indoor environments can be particularly tricky. This is because insecticide applications and other non-chemical and exclusion techniques need to be deployed both inside homes or apartments that are frequently visited by this pest and also at their harborage/ breeding sites in the peri-domestic environment. Common examples of locations where American cockroaches could reside and breed are steam tunnels, manholes, sewers etc. This presentation focuses on laboratory-based studies that demonstrate effectiveness of various liquid and bait insecticides for controlling American cockroaches.

The Asian Cockroach: Biology and Management Implications from Research

Madison Peterson, Xing Ping Hu, and Arthur G. Appel

Auburn University

Abstract

The Asian cockroach, *Blattella asahinai* Mizukubo, is a peridomestic nuisance pest in the southeastern United States. *Blattella asahinai* is the closest relative to *Blattella germanica* (L.), the domestic German cockroach. Because these two species live in different habitats, they may have differential development. Development of *B. asahinai* and *B. germanica* nymphs were observed at six constant temperatures (10 - 35˚C). At 10˚C and 15˚C, all nymphs died in the first instar, but *B. germanica* nymphs survived longer (10˚C: 13.07 d; 15˚C: 43.31 d) than *B. asahinai* nymphs (10˚C 8.2 d; 15˚C 17.52 d). At 20˚C, 25˚C, and 30˚C, *B. asahinai* had more instars and longer stadia than *B.*

*germanic*a. At 35˚C, only *B. germanica* completed nymphal development. Comparative water relations experiments at 30˚C and 0% RH indicated that *B. asahinai* had a cuticular permeability of ≈30 μg cm-2 h-1 mmHg-1, nearly double that of *B. germanica*. *Blattella asahinai* preferred moist substrates and required drinking water. Preliminary field experiments indicate that mulch selection and management, reduction of standing water, removal of fallen fruits and flowers, as well as the use of yellow or LED porch lights reduce *B. asahinai* populations around homes and minimize the potential of indoor intrusions.

SUBMITTED PAPERS: TERMITES AND COCKROACHES

Alate Monitoring after Area-wide Control of the Formosan Subterranean Termite, *Coptotermes formosanus* in the French Quarter and Jackson Barracks

Mark Janowiecki, Carrie Cottone, and Claudia Riegel

New Orleans Mosquito, Termite, and Rodent Control Board

The invasive Formosan subterranean termite, *Coptotermes formosanus*, is the most destructive structural pest in Louisiana, costing more than $300 million annually in the Greater New Orleans Area for remedial and preventative treatment, damage, and repairs. To protect the historic French Quarter section of New Orleans, Operation Full Stop, an area-wide termite control strategy, was conducted from 1998-2012. Alate monitoring was used as a determination of success, assuming if termite colonies were eliminated, the number of alates would decrease. Extensive alate trapping in the French Quarter showed a significant decrease in swarm sizes even to this day. In 2014, an area-wide control strategy was established at Jackson Barracks, New Orleans, Louisiana. Alate monitoring at the Barracks began in 2015 to determine the relative risk of incipient colonies being established in the area. Despite the elimination of colonies within Jackson Barracks, there is still high alate pressure. To understand this discrepancy between the French Quarter and Jackson Barracks, we collected from the alate monitors and characterized the genetic structure of these swarms using established microsatellite markers. Through pedigree analysis, we found swarms in the Jackson Barracks had about three times as many colonies contributing than swarms in the French Quarter. This indicates that although termite control was successful in protecting structures, there is still high termite pressure in Jackson Barracks likely from nearby swarming colonies outside our area wide control.

Detoxification and Antimicrobial Responses to Defined Insecticide Selection Pressures in the German Cockroach (*Blattella germanica* L.)

Michael E. Scharf[1] and Ameya D. Gondhalekar[2]

[1]University of Florida, [2]Purdue University

Abstract

Cockroaches are important global urban pests from aesthetic and health perspectives. Insecticides represent the most cost-effective way to control cockroaches and limit their impacts on human health. However, cockroaches readily develop insecticide resistance, which can quickly limit efficacy of even the newest and most effective insecticide products. The goal of this research was to understand whole-body physiological responses in German cockroaches, at the meta-transcriptome level, to defined insecticide selection pressures. We used the insecticide indoxacarb as the selecting insecticide, which is an important bait active ingredient. Six generations of selection with indoxacarb bait produced a strain with substantial (>20×) resistance relative to inbred control lines originating from the same parental stock. Metatranscriptome sequencing revealed 1,123 significantly differentially expressed (DE) genes in ≥two of three statistical models (81 upregulated and 1,042 downregulated; FDR $P < 0.001$; log2 Fold Change of ±1). Upregulated DE genes represented many detoxification enzyme families including cytochrome-P450 oxidative enzymes, hydrolases and glutathione-S-transferases. Interestingly, the majority of downregulated DE genes were from microbial and viral origins, indicating that selection for resistance is also associated with elimination of commensal, pathogenic and/or parasitic microbes. These microbial impacts could result from: (i) direct effects of indoxacarb, (ii) indirect effects of antimicrobial preservatives included in the selecting bait matrix, or (iii) selection for general stress response mechanisms that confer both xenobiotic resistance and immunity. These results provide novel physiological insights into insecticide resistance evolution and mechanisms, as well as novel insights into parallel fitness benefits associated with selection for insecticide resistance.

Efficacy of a 'Solutions Approach' for Area-Wide Control of Subterranean Termites (Blattodea: Rhinotermitidae *Coptotermes formosanus* and *Reticulitermes* sp.) in Scottsdale, AZ, Mobile, AL, and Okaloosa, FL

Kyle K. Jordan, Carrie Cottone, Matthew Spears, Faith Oi, Robert Hickman, Claudia Riegel

Abstract

Three complex sets of structures with historic or community significance were experiencing substantial subterranean termite activity. A ‘solutions approach’ – use of multiple formulations/products – was used to protect each of these sites from termites. This approach is especially important for structures that have historical significance since termites need to be effectively controlled with as little disturbance or risk of damage as possible to the structures and surrounding areas. These treatments implemented combinations of termite baiting, liquid termiticides, and foam, and resulted in elimination of termite activity in the structures with minimal disruption to the structures, grounds, and the personnel working in and visiting the sites.

Key Words Trelona, Novaluron, Termidor, Fipronil, Area-wide

SUBMITTED PAPERS: PLANT AND STORED PRODUCT PESTS

RNAi-mediated Silencing of Vitellogenin Gene Curtails Oogenesis in the Almond Moth *Cadra cautella*

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[1] Plant Protection Department, Economic Entomology Research Unit, College of Food and Agriculture, Sciences, King Saud University, Riyadh, Saudi Arabia, [2] Ghazi University, Dera Ghazi Khan, Punjab, Pakistan, [3] National Center for Agricultural Technology (NCAT), King Abdulaziz City for Science and Technology (KACST), Riyadh, Saudi Arabia

Abstract

Vitellogenins, major yolk protein precursors, play an essential role in the reproduction and spread of all oviparous species, including insects. To investigate reproductive strategies of the warehouse moth *Cadra cautella* at the molecular level, a partial transcript of the *C. cautella* vitellogenin (CcVg) gene was extended through the rapid amplification of cDNA ends PCR and sequenced. The complete CcVg mRNA transcript was 5,334 bp long, which encoded a protein of 1,778 amino acids, including the first 14 amino acids of the signal peptide. The deduced CcVg protein contained a putative cleavage site (RTRR) at the amino-terminal side, similar to several other insect species. DGQR and GI/LCG motifs were present at the CcVg gene C-terminus, followed by nine cysteine residues. CcVg harbored 131 putative phosphorylation sites, numbering 84, 19, and 28 sites for serine, threonine, and tyrosine, respectively. The transcript showed

a great resemblance with other lepidopteran Vgs. CcVg protein analysis revealed three conserved regions: 1) vitellogenin-N domain, 2) DUF 1943 (domain of unknown function), and 3) a von Willebrand factor type D domain. Additionally, sex, stage-specific, and developmental expression profiles of the CcVg gene were determined through RT-PCR. The Vg was first expressed in 22-day-old female larvae, and its expression increased with growth. The phylogenetic analysis based on different insect Vgs revealed that the CcVg exhibited close ancestry with lepidopterans. The CcVg-based RNAi experiments were performed, and the effects were critically evaluated. The qRT-PCR results showed that CcVg-based dsRNA suppressed the Vg gene expression up to 90% at 48 h post-injection. Moreover, CcVg-based RNAi effects resulted in low fecundity and egg hatchability in the CcVg-based dsRNA-treated females. The females laid eggs, but because of insufficient yolk protein availability the eggs could not succeed to hatch. The significant difference in the fecundity and hatchability unveils the importance of CcVg gene silencing and confirmed that the Vg gene plays a key role in *C. cautella* reproduction and it has the potential to be used as a target for RNAi-mediated control of this warehouse pest.

Acknowledgments
This project was funded by the National Plan for Science, Technology, and Innovation (MAARIFAH), King Abdulaziz City for Science and Technology, Kingdom of Saudi Arabia, Award Number (2-17-04-001-0044). The authors also thank the Research Support ServiceUnit at King Saud University for their technical support.

SYMPOSIUM: COMMERCIALIZATION OF PEST MANAGEMENT: EXPECTATION VS. REALITY

Rarely does pest management go the way it is envisioned. Challenges with customer preparation, site-specific differences, human behavior, and pest biology all change the dynamics of the plan into the reality that pest management professionals encounter on any given day. In this session, we will discuss examples of four pests of concern in varying environments including residential, commercial, and large scale/industrial and how the pest management expectation quickly changed to the reality of control.

Termites

Glen Ramsey

Rollins, Inc.

Rodents

Ian Williams

Rollins, Inc.

Bud Bugs

Benjamin Hottel

Rollins, Inc.

Stored Product Pests

Frank Meek

Rollins, Inc.

SUBMITTED PAPERS: ANTS, BEES, AND WASPS

Expansion of the European Fire Ant in the Pacific Northwest

Laurel D. Hansen

Spokane Falls Community College; Washington State University

Identification of the European fire ant, *Myrmica rubra* as a pest species was made in 2006 in the Seattle, Washington and Victoria and Vancouver areas of British Columbia. The spread of this ant was monitored 2010-2020 in Seattle by sampling surrounding areas and enlisting assistance from pest management personnel servicing the adjacent areas.

Myrmica rubra, is native to Northern Europe and was introduced into Boston about 1900 where it has become a health and ecological risk (Broden et al. 2005) and spread throughout the New England area and Southeastern Canada. The large colonies are polygynous and polydomous that spread by budding. Colonies nest in wet soil, often under rocks and pavers (Hicks and Marshall 2018). The ant has an aggressive stinging behavior. In 2010, the ant was identified in the greater Vancouver area of British Columbia along the Fraser River delta in community gardens and residential areas. The ant was also found in the Oak Bay area of Victoria on Vancouver Island in yards and lawns.

In the Seattle area *Myrmica rubra* was collected in 1988 as reported by Wetterer and Radchenko (2011). Ants collected in 2006 by pest management professionals were positively identified in 2011 both in the Seattle area and in British Columbia. The Washington Park Arboretum in Seattle, where the ants were first collected continued to be sampled from 2006-2016 with the assistance of the Washington State Department of Agriculture with emphasis around Lake Washington, a fresh-water lake nearly 21 miles in length. Ants were collected on Foster Island and Marsh Island, part of the Washington Park Arboretum bordering Lake Washington.

With grants from the Norm Ehmann Urban Pest Management Program, Washington State University, sampling in the Seattle area occurred 2017-2019 with emphasis on Foster Island and Marsh Island that include part of the Waterfront Trail through Washington Arboretum. Sampling was accomplished using litter sifting with Winkler extraction, baiting along transect lines, and point sampling. Ants were also collected where the trail adjoins the mainland at either end of the trail, throughout Marsh Island, and other areas in Foster Island.

In 2019, ants were reported at an additional area of University of Washington, Yesler Swamp, about one mile north of the Washington Park Arboretum. This area is also located on Lake Washington, north of the Lake Washington Ship Canal and the Union Bay Natural Area. This area is undeveloped, and includes wetlands with recreational trails. This natural area was sampled in 2020 using transect lines and 90 baiting sites. *M. rubra* was collected in 22 of these sites.

Seattle Parks and Recreation has a grant to renovate the Waterfront Trail in the Washington Park Arboretum. Construction was delayed due to the Covid pandemic but is scheduled to resume in 2023. Current concern is over the disposal of the trail materials composed of wooden borders and packed sawdust that are both infested with *M. rubra*. Higgins (2021) cautions the importance of proper disposal of infected soil and materials after the comprehensive study of spread in British Columbia.

Questions that need to be answered or ‘where do we go from here’ warrants three issues:

1. Do the ants in the two Seattle sites constitute a ‘supercolony’?
   Intra-aggression studies and mtDNA-relatedness of colonies could be used to demonstrate supercolonies as was accomplished in Vancouver, British

Columbia where at least two large multi-nest supercolonies were identified (Naumann, et al. 2017).
2. Taxonomy of Myrmica spp. is challenging (Higgins 2015). There are 13 species of *Myrmica* in British Columbia: at least 3 species are introduced (*M. rubra, M. speciodes, M. scabrinodis*) from Europe with *M. rubra* being the most aggressive. Could pest management professionals (PMPs) be employed to screen for the occurrence of *Myrmica*? Currently PMPs attend ant identification workshops and are supplied with *M. rubra* as one of the 30 ants provided for personal collections.
3. Is the density of local ant populations and other arthropods threatened by the introduction of *M. rubra*? Studies in British Columbia indicate the impact of this ant on native populations (Nauman and Higgins 2015) has been severe. In the 2020 collections made in Washington Park Arboretum, Yesler Swamp, and Union Bay Natural Area, no other ant species were collected other than *M. rubra*.

Summary: Investigations in Seattle of *M. rubra* and other *Myrmica* spp. in these ecologically sensitive urban areas have not been made. Results of sampling and monitoring indicate the ant has expanded along the wetlands of Lake Washington.

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Management of the Invasive Dark Rover Ant (*Brachymyrmex patagonicus* Mayr) with PT® Alpine® Pressurized Fly Bait and Vedira™ Pest Management Products

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Abstract

Brachymyrmex patagonicus Mayr is an invasive ant species thought to have originated in Argentina/Paraguay. It was identified in the U.S. in 1976 in Louisiana and Florida (Wheeler 1978) and in Mississippi in 1977. Ants of the genus "*Brachymyrmex*" are referred to as 'rover ants', and the common name 'dark rover ant' is associated with *B. patagonicus*. This ant has expanded its range since the mid 1970's and is now well established in AL, AR, FL, GA, LA, MS, TX and urban centers in the southwest US (NV and AZ) and it's range continues to enlarge. It is established in Houston, Dallas and San Antonio, TX (Wild 2008), and has been recorded in SC (MacGown et al. 2010) & southern CA (Martinez 2010). The potential range for B. patagonicus may be as far north as TN (MacGown et al. 2010). The efficacy of PT® Alpine® Pressurized Fly Bait, PT® Vedira™ Pressurized Insecticide, Vedira™ Pressurized Fly Bait and Vedira™ Granular Ant Bait on *B. patagonicus* was evaluated. PT® Vedira™ Pressurized Insecticide provided 100% mortality within 15 minutes with topical treatment & faster efficacy was observed on freshly dried mulch (>95% mortality @ 30 minutes after treatment (MAT)) and tile (>95% mortality @ 60 MAT) treatments than on concrete (100% @ 24 HAT). PT® Alpine® Pressurized Fly Bait (96% mortality @ 6 days after exposure (DAE)), Vedira™ Pressurized Fly Bait (93% mortality @ 15 DAE) and Vedira™ Granular Fly Bait (95% @ 1 DAE) provided high levels of dark rover ant mortality. InTice™ Rover Ant Bait (Rockwell Labs Ltd.) provided minimal efficacy in this trial (2% mortality @ 15 DAE). PT® Alpine® Pressurized Fly Bait, Vedira™ Pressurized Fly Bait, Vedira™ Granular Ant Bait and PT® Vedira™ Pressurized Insecticide are favorable candidate products for Rover Ant management.

Methodology of EPA Fire Ant Efficacy Testing Guidelines (OCSPP 810.3100)

Hester Dingle, Deanna Colby, Virna Stillwaugh

Environmental Protection Agency

Abstract

EPA-registered pesticide products are an important part of pest management programs to accomplish control of invertebrate public health pests. The Agency has recently revised several guidelines to assist in the development of appropriate protocols to test product efficacy in support of pesticide registration. EPA Product Performance Test Guidelines 810.3100 Treatments for Imported Fire Ants was revised and published in 2021. The guideline was revised to increase clarity and consistency in efficacy testing methodology. The methods associated with Guidelines 810.3100 Treatment for Imported Fire Ants will be discussed in detail.

The Development and Evaluation of Baiting Strategies for Control of Pest Yellowjackets in California

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The western yellowjacket, *Vespula pensylvanica* Saussure, and *Vespula alascensis* Packard are significant seasonal pests in recreational and urban settings in the western United States. Both species are widely disturbed across western Canada and the United States. They readily forage on human foods and are frequently encountered in parks, recreational areas, and urban settings adjacent to native habitats. The only toxicant currently registered in the US to incorporate into baits is esfenvalerate (OnSlaught). Esfenvalerate baits were ineffective against western yellowjackets (Rust et al. 2010).

The objectives of the study were 1) to develop attractive and palatable baits, 2) to extend the longevity of baits in the field, and 3) to test active ingredients with delayed toxicity.

Materials and Methods

Sites. The studies were conducted in the San Francisco Bay, the Lake Tahoe area, and southern California. The sites included recreational parks, an RV park, a wild animal park, and campgrounds. The species composition of yellowjackets varied at each location, but the predominant species was *V. pensylvanica*.

Baits. The 0.025% fluralaner bait was prepared by mixing 420 g of minced chicken, 60 ml of chicken juice, and 0.4 ml fluralaner (Bravecto® 250 mg/ml, Intervet Inc., Madison, WI). The 0.05% fluralaner bait was prepared with 250 ml of chicken juice, 250 ml of deionized water, 33.33 g of polyacrylamide crystals (PAA, Watering Storing Crystals, Miracle-Gro Lawn Products, Inc., Marysville, OH), and 0.8 ml of Bravecto. The 0.096% selamectin + 0.016% sarolaner bait was prepared with 250 ml of chicken juice, 250 ml of deionized water, 33.33 g of PAA crystals, and 8 tubes of Revolution Plus (Revolution® Plus, Zoetis, Inc., Kalamazoo, MI). The baits were allowed to condition in the refrigerator overnight.

Monitoring. Different traps were used for monitoring yellowjackets depending upon the sites. The Placer-style yellowjacket trap is a durable, reusable design. The volatile chemical lure heptyl butyrate is highly attractive to western yellowjacket workers and queens (Landolt et al. 2003). Placer-style traps were hung in trees to prevent bears and other animals from disturbing them. These traps were utilized at the Lake Tahoe sites. The UCR-style trap was used at most of the sites where bears were not an issue (Reierson and Wagner 1975). The monitoring periods varied from 1 to 3 weeks depending upon the sites.

Bait Stations. The UCR-style bait stations were constructed from two pieces of pine board about 18 x 18 cm and 1.8 cm thick and a piece of 2.54 cm hardware cloth (Rust et al. 2010). UCR plastic circular bait stations were constructed from plexiglass disks (29.2 diam, 5 mm thick, 2.54 cm PVC pipe and hardware cloth. A ring of hardware cloth (8.9 by 91.7 cm) separated the disks and allowed yellowjackets to enter the bait station. The bait stations were hung from a bush, tree, or Shepard's hook with a wire.

The stations were suspended from a wire and a Perky-Pet® ANT GUARD® (Woodstream Corp., Lititz, PA) to prevent ants from feeding on the baits.

Evaporation Controls. To adjust for the water that evaporated from the baits during the exposure period, baits were placed in salsa cups in the above stations covered with window screen. The entire bait cup (cup + lid + bait) was weighed. After the exposure period, the cups were sealed with the lids, returned to the laboratory, and weighed. The ratio of water loss was determined as [Evaporative Initial Bait weight (EIBw)- Evaporative Final Bait weight (EFBw)/Evaporative Initial Bait weight (EIBw)] for the cups placed in the evaporation control stations. The average ratio of the EIBw/EFBw was also calculated. The following calculation was used to determine the amount of bait or food material taken by the yellowjackets with corrections for the water loss of the bait remaining at the end of the exposure. The amount of bait taken = Initial Bait weight – [Avg. EIBw/EFBw x (Final Bait weight)].

Statistical Analyses. The pre- and post-baiting trap counts were analyzed with a Wilcoxon signed-rank test (Statistix 13).

Results

Bait Efficacy Trials. Baits containing 0.025% fluralaner in minced chicken significantly reduced the number of yellowjackets trapped for at least 28 days at the Richmond Field

Station (Table 1). The yellowjackets readily accepted the minced chicken baits. The three traps nearest the site where bait was applied had consistently greater reductions in the number of yellowjackets trapped than traps farther away. Even though the control site was some 400 m from the test site, there was a significant reduction in the number of yellowjackets trapped at 34 days at one of the untreated sites (B).

The 0.05% fluralaner and 0.096% selamectin + 0.016% sarolaner provided significant reductions in yellowjacket trap counts for at least 28 days at Ronald W. Caspers Wilderness Park (Table 2). The yellowjackets readily accepted the bait. At day 28, the yellowjacket numbers significantly declined in the untreated controls.

Discussion

Numerous toxicants have been tested in bait matrices against *V. pensylvanica, V. germanica*, and *V. vulgaris*, but they are often too toxic, fast-acting, and ineffective (Rust et al. 2010, Rust and Su 2012). Yellowjacket baits consisting of chicken and fipronil effectively provide area-wide control (Hana et al. 2012; Rust et al. 2010, 2017). The longevity of the fipronil bait was extended by incorporating chicken juice into polyacrylamide hydrogels (Choe et al. 2018).

Only a limited number of active ingredients have been successfully incorporated into baits to control yellowjackets. Baits with the two isoxazoline compounds, fluralaner and sarolaner, were readily accepted and provided excellent reductions (> 90%) in the number of yellowjackets trapped.

To achieve areawide control, much larger areas will need to be baited. Numerous yellowjacket colonies forage within the same area. To ensure that a colony forages enough bait to eliminate the colony, more bait stations will be needed. In addition, a second or third baiting maybe necessary to control populations that move into previously baited areas.

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Table 1. Efficacy of 0.025% fluralaner in minced chicken baits at the Richmond Field Station on 8/26/2020.

Traps	Average YJ/T/D (% reduction)[a]			
	Pre-bait	Day 20	Day 27	Day 34
3 traps nearest bait	26.9	1.5 (94.3%)*	3.4 (83.7%)*	1.4 (93.3%)*
All 9 traps	20.2	3.0 (84.9%)*	5.6 (72.2%)*	5.0 (75.3%)*
Untreated transect B	6.1	4.9 (19.1%)	11.9 (0.0%)	2.3 (62.4%)*
Untreated transect C	4.4	16.8 (16.8%)	9.2 (0.0%)	34.0 (8.9%)

[a] YJ/T/D = number of yellowjackets trapped per trap per day. Asterisk denotes a significant reduction ($P < 0.05$, Wilcoxon signed-rank test).

Table 2. The efficacy of 0.05% fluralaner and 0.096% selamectin + 0.016% sarolaner hydrogel baits at Ronald W. Caspers Wilderness Park on 8/13/2021.

Toxicant	*Bait Taken (g)*	*Average YJ/T/D (% reduction)[a]*			
		Pre-bait	*9-10 days*	*14-15 days*	*27-28 days*
Fluralaner	*316.1*	*4.26*	*1.25 (78.4%)**	*1.35 (76.6%)**	*0.75 (87.0%)**
Selamectin + Sarolaner	*384.5*	*5.78*	*0.45 (92.2%)**	*0.71 (87.8%)**	*0.40 (93.1%)**
Untreated		*8.19*	*11.18 (0.0%)*	*5.19 (36.6%)*	*2.43 (70.3%)**

[a] YJ/T/D = number of yellowjackets trapped per trap per day. Asterisk denotes a significant reduction ($P < 0.05$, Wilcoxon signed-rank test).

Coastal Georgia Pest Risk Committee: Protecting the Honey Bee Industry at the Georgia Ports Authority

Timothy s. Davis

University of Georgia Extension

Abstract

The Federal Honey Bee Act protects the Honey Bee Industry by regulating the importation of all Honey Bee (*Apis malifera*) and honey bee related equipment. An Extension program was conducted to bring the Georgia Ports Authority, and local bee keepers into compliance with the Federal Honey Bee Act. The program targeted the departments at the Georgia Ports Authority, agricultural inspectors, honey bee keepers, Georgia Farm Bureau, and Pest Control Operators.

Comparison of Fire Ant Control by Water-resistant and Standard Fire Ant Baits Exposed to Irrigation

David H. Oi[1], Rachel A. Atchison[1], Jian Chen[2], Gerald Chuzel[3], Jennifer A. Henke[3], and Ronald D. Weeks[4]

[1]USDA-ARS Center for Medical, Agricultural, & Veterinary Entomology, [2]USDA-ARS, National Biological Control Laboratory, [3]Coachella Valley Mosquito and Vector Control District [4]USDA, APHIS, PPQ, Science & Technology

Abstract

The red imported fire ant, *Solenopsis invicta* (Buren), is an invasive pest of agricultural, urban, and natural areas which can be controlled by commercially available fire ant baits. Fire ant baits typically consists of toxicant dissolved in a food attractant, such as soybean oil, which is absorbed onto a corn grit carrier. However, rain or irrigation are thought to degrade the carrier when it absorbs water, resulting in compromised bait effectiveness. We assessed the effect of irrigation on the efficacy of water-resistant and standard fire ant bait formulations, by comparing fire ant colony survivorship after access to irrigated, bait-treated sod. In initial testing, wetted water-resistant and standard baits reduced fire ant colonies less than dry baits, both when baits were given to colonies directly and when colonies were given access to baits broadcasted (i.e., scattered) atop sod. Comparisons of the efficacy of piled versus broadcast applications

of water-resistant and standard baits revealed reductions of >88% in adults and brood and no surviving queens for all bait treatments. This result was unexpected because bait granules in the interior of the bait pile were hypothesized to be better protected from irrigation than broadcast bait applications. In a field study, irrigated water-resistant and standard baits caused similar and significantly higher reductions in fire ant foraging activity relative to an untreated control. These results indicated that both the water-resistant and standard fire ant bait provided significant fire ant reductions even after irrigation. Details of the methods and results of these studies have been published in Oi, D. H., R. A. Atchison, G. Chuzel, J. Chen, J. A. Henke, and R. D. Weeks. 2022. Effect of irrigation on the control of red imported fire ants (Hymenoptera: Formicidae) by water-resistant and standard fire ant baits. Journal of Economic Entomology 115: 266-272.

Fire Ants – Remote Surveillance in Support of Containment and Eradication

Grant Mack

Outline Global

2022 NCUE Planning Committee

Conference Chair:	Molly Keck, Texas A&M AgriLife Extension
Program Chair:	Carrie Cottone, New Orleans Mosquito, Termite & Rodent Control Board
Awards Chair:	Allie Allen, NPMA
Treasurer:	Edward L. Vargo, Texas A&M University
Treasurer:	Lisa Jordan, Texas A&M University
Secretary:	Erin Monteagudo, Veseris
Local Arrangements:	Kevin Thorne, Utah Pest Control Association and Ary Faraji, Salt Lake City Mosquito Abatement District
Sponsorship Chair:	Daniel R. Suiter, University of Georgia
Sponsorship Committee:	Stewart Clark, Hao Yu, Rentokil, and Fudd Graham, Auburn University

NCUE Bylaws

BYLAWS

NATIONAL CONFERENCE ON URBAN ENTOMOLOGY

ARTICLE I- NAME The name of this organization is the National Conference on Urban Entomology. ARTICLE II-BACKGROUND In the spring of 1985, individuals representing urban entomology and the pest control industry came together to organize a national conference to be held biennial. The mission of these conferences was to open channels of communication and information between scientists in industry, academia, and government, and to foster interest and research in the general area of urban and structural entomology.

The primary scope of the National Conference is to emphasize innovations and research on household and structural insect pests. It is the intent; however, to provide flexibility to include peripheral topics that pertain to the general discipline of urban entomology. It is anticipated that the scope of the conference could change through time, but the emphasis would be to provide an opportunity for urban entomologist to meet on a regular basis. It is not anticipated that any specific memberships would be required or expected, but that the cost associated with the conference would be met through registration fees and contributions. In the event that funds become available through donations or from the sale of conference proceedings, that these resources will be spent to meet expenses, to pay the expenses for invited speakers, and to provide scholarships to qualified students working in urban entomology. It is the intent of this organization to be non-profit, with financial resources provided to the Conference to be used entirely in support of quality programming and the support of scholarships.

ARTICLE III-OBJECTIVES
The objectives of this organization are:

1. To promote the interest of urban and structural entomology.

2. To provide a forum for the presentation of research, teaching and extension programs related to urban and structural entomology.

3. To prepare a written/electronic proceedings of all invited and accepted papers given or prepared at the biennial meeting.

4. To promote scholarship and the exchange of ideas among urban entomologists.

5. As funds are available, scholarships will be awarded to students pursuing scholastic degrees in urban entomology. Three levels of scholarships will be offered: the first level is for Bachelor students; the second level is for Masters students; and the third level is for Ph.D. candidates. These students must register for, and attend, the conference and present the paper in order to receive funding. These scholarships will be awarded

based solely on the merits of the candidates, and the progress that they have made towards completion of their research and scholastic degrees. The student will receive funding only if they are currently enrolled in a university at the time that the conference is held.

6. There may also be first, second, and third place recipients of an onsite student competition for students who are currently involved in their undergraduate or graduate programs. These students can compete for scholarship funds; however, if any student has already been awarded a scholarship for the current meeting, and wishes to participate in this onsite competition, their presentation must be completely separate, and they must be properly registered in advance for this competition.

ARTICLE IV-JURISDICTION

The jurisdiction of this conference is limited to events held within the United States of America; however, we will be supportive of international urban entomology conferences as they are organized and held.

ARTICLE V-MEMBERSHIP

There are no membership requirements associated with this organization except for the payment of registration fees which go to offset the cost of holding the conference, preparation/printing of proceedings and the offering of scholarships. All persons with an interest in urban entomology are invited to attend the conferences and associated events.

ARTICLE VI-OFFICERS

Leadership for the Conference will be provided by the Chair of the Conference Committee. The Executive committee will be composed primarily of representatives from academia, industry and government. There will be seven officers of the Executive Committee and will include the following:

- Chair of the Conference Committee
- Chair of the Program Committee
- Chair of the Awards Committee
- Secretary to the Conference
- Treasurer to the Conference
- Chair of the Sponsorship Committee
- Chair of the Local Arrangements Committee

The Chair of the Conference Committee will preside at all Committee meetings, and will be the Executive Officer for the organization, and will preside at meetings. In the absence of the Chair of the Conference Committee, the Chair of the Program Committee may preside. The voting members for executive decisions for the conference will be by a majority vote of a quorum which is here defined as at least five officers.

The duties of the officers are as follows:

Chair of the Conference Committee: To provide overall leadership for the Conference, to establish ad hoc committees as needed, and to solicit nominations for new officers as needed.

Chair of the Program Committee: To coordinate the conference in terms of arranging for invited speakers and scientific presentations as well as oversee the printing of announcements, programs and proceedings.

Chair For Awards: To oversee and administer the Mallis Award, scholarships and other honors or awards as approved by the executive committee.

Secretary: To take notes and provide minutes of meetings.

Treasurer: Provide documentation of expenditures, and the collection and disbursement of funds. To act on behalf of the executive committee in making arrangements with hotels, convention centers and other facilities in which conferences are held.

Chair For Sponsorship: This committee will be involved in fund raising and in seeking sponsorship for various aspects of the conference. It will also contact contributors and potential contributors to seek donations and support for the conference and associated events. It is anticipated that the committee will be composed of at least one member representing academia, and one member representing industry.

Chair For Local Arrangements: To gather information on behalf of the executive committee for hotels, convention centers and other facilities in which the conference is to be held. To arrange for audio/visual equipment, and to oversee the general physical arrangements for the conference.

ARTICLE VII-TERMS OF OFFICE & SUCCESSION OF OFFICERS:
Officers may serve for a maximum of four conference terms (8 years); however, if no new nominations are received, the officers may continue until such time as replacements are identified and installed. The Awards Chair is the last position to be served, and may be relieved from NCUE officer duties unless asked or willing to serve NCUE in another capacity. The Conference Chair may serve for one conference after which time they will become the Chair of the Awards Committee. The Program Chair may serve for one conference term after which time they will become the Conference Chair. The Secretary may serve for one conference term, after which time they will become the Program Chair. The Chair for Local Arrangements should change with each conference unless the meetings are held in the same location. The Chair the Sponsorship Committee (to include both an academic and industry representative) will serve for two conferences. The Treasurer will serve for two conference cycles, unless reappointed by the Executive Committee.

ARTICLE VIII-NOMINATION OF OFFICERS
Nominations for any of the chair positions may come from any individual, committee, or subcommittee, but must be forwarded to the Chair of the Conference before the final

business meeting of each conference. It is further anticipated that individuals may be asked to have their names put into nomination by the Chair of the Conference. In the event that there are no nominations, the existing Chair may remain in office with a majority vote of the Executive Committee for the conference. It is clearly the intent of these provisions that as many new people be included as officers of this organization as is possible, and no one shall be excluded from consideration.

ARTICLE IX-MEETINGS

Conferences of the National Conference on Urban Entomology will be held every two years. Meetings of the officers of this organization will meet at least annually either in direct meetings or by conference calls in order to plan the upcoming conference, and to conduct the business of the organization.

ARTICLE X-FINANCIAL RESPONSIBILITIES

All financial resources of the Conference will be held in a bank under an account named, "National Conference on Urban Entomology", and may be subjected to annual audits. Expenditures may be made in support of the conference, for scholarships and other reasonable costs; however, funds may not be used to pay officers', or their staff's salaries, or for officers' travel expenses. In the event that this organization is disbanded, all remaining funds are to be donated to the Endowment Fund of the Entomological Society of America.

ARTICLE XI-FISCAL YEAR

The fiscal year will run from January 1 through December 31 of each year.

ARTICLE XII-AMENDMENTS

The bylaws for this organization may be amended by a two-thirds affirmative vote of the attendees at the business meeting, provided that the proposed amendments are available for review at least 48 hours in advance of the voting.

ARTICLE XIII-INDEMNIFICATION

The National Conference on Urban Entomology shall indemnify any person who is or was a party, or is or was threatened to be made a party to any threatened, pending or completed action, suit or proceeding, whether civil, criminal, administrative or investigative by reason of the fact that such person is or was an officer of the Committee, or a member of any subcommittee or task force, against expenses, judgments, awards, fines, penalties, and amount paid in settlement actually and reasonably incurred by such persons in connection with such action, suit or proceeding: (I) except with respect to matters as to which it is adjudged in any such suit, action or proceeding that such person is liable to the organization by reason of the fact that such person has been found guilty of the commission of a crime or of gross negligence in the performance of their duties, it being understood that termination of any action, suit or proceeding by judgment, order, settlement, conviction or upon a plea of nolo contendere or its equivalent (whether or not after trial) shall not, of itself, create a presumption or be deemed an adjudication that such person is liable to the organization by reason of the commission of a crime or gross negligence in the performance of their duties; and (II) provided that such person shall have given the organization prompt notice of the threatening or commencement (as appropriate) of any such action, suit or proceeding. Upon notice from any such indemnified person that there is threatened or has been commenced any such action, suit or proceeding, the organization: (a) shall defend such indemnified person through counsel selected by and paid for by the organization and reasonably acceptable to such indemnified person which counsel shall assume control of the defense; and (b) shall reimburse such indemnity in advance of the final disposition of any such action, suit or proceeding, provided that the indemnified person shall agree to repay the organization all amounts so reimbursed, if a court of competent jurisdiction finally determines that such indemnified persons liable to the organization by reason of the fact that such indemnified person has been found guilty of the commission of a crime or of gross negligence in the performance of their duties. The foregoing provision shall be in addition to any and all rights which the persons specified above may otherwise have at any time to indemnification from and/or reimbursement by the organization.

Modified: 5/19/10-passed