PROCEEDINGS OF THE 2008 NATIONAL CONFERENCE ON URBAN ENTOMOLOGY

MAY 18 – 21, 2008
TULSA, OK

CORPORATE SPONSORS

To be a corporate sponsor of the National Conference on Urban Entomology is to be a benefactor of programs supported by the conference, a supporter of current entomological activities in the areas of urban entomology, and a partner in promoting a better understanding of the science of urban entomology. The following are the National Conference on Urban Entomology corporate sponsors for 2008 (in alphabetical order):

BASF Corporation
Bayer Environmental Science
Dow AgroSciences
DuPont Professional Products
MGK-McLaughlin Gormley King Company
Orkin, Inc.
Pest Control Technology Magazine
Pest Management Professional Magazine
S. C. Johnson & Son, Inc.
Syngenta Crop Protection, Inc.
Terminix International
Whitmire Micro-Gen

THANK YOU FOR YOUR SUPPORT!

Proceedings cover was adapted from Tim Cabrera's design for the *2008 National Conference on Urban Entomology Program* cover, which reflected the theme "Urban Pest Roundup."

PROCEEDINGS OF THE 2008 NATIONAL CONFERENCE ON URBAN ENTOMOLOGY

Edited by
Susan C. Jones

ACKNOWLEDGMENTS

David J. Shetlar (Ohio State University) generously provided expertise with graphics and print formatting; his assistance was invaluable. I would like to thank Megan E. Meuti, Lauren N. Tryon, and El-Desouky Ammar (Ohio State University) for help inputting and formatting text and proofreading the manuscript. Karen M. Vail (University of Tennessee), Dini M. Miller (Virginia Tech), and Laura Nelson (Texas A&M University) also are thanked for their assistance with various aspects of the *Proceedings*. Tim Cabrera is gratefully acknowledged for designing the *2008 National Conference on Urban Entomology Program* cover.

TABLE OF CONTENTS

National Conference On Urban Entomology May 18-21, 2008 Tulsa, Oklahoma U.S.A.

DISTINGUISHED ACHIEVEMENT AWARD IN URBAN ENTOMOLOGY

STUDENT SCHOLARSHIP AWARD PRESENTATIONS

STUDENT PAPER COMPETITION

SUBMITTED PAPERS: COCKROACHES & GENERAL PESTS

TEACHING SYMPOSIUM: GETTING STUDENTS HOOKED ON BUGS

SYMPOSIUM: BIODIVERSITY OF TERMITES FROM THE AMERICAS

SUBMITTED PAPERS: TERMITES

SUBMITTED PAPERS: ANTS & BEES

SYMPOSIUM: GLIMPSE OF NOVEL CHEMISTRY/TECHNOLOGY IN TERMITE MANAGEMENT

SYMPOSIUM: ASSESSMENT AND IMPLEMENTATION OF IPM IN SCHOOLS

SUBMITTED PAPERS: POWDERPOST BEETLES, FORMOSAN TERMITES & OTHER NEW ORLEANS' PESTS

SYMPOSIUM: BLOOD-SUCKING HITCHHIKERS – THE RETURN OF FLEAS AND TICKS

SUBMITTED PAPERS: PUBLIC HEALTH PESTS

SYMPOSIUM: TERMITE BEHAVIOR: BETTER UNDERSTANDING FOR BETTER CONTROL

SYMPOSIUM: EMERGING INVASIVE PEST ANTS OF IMPORTANCE

DISTINGUISHED ACHIEVEMENT AWARD IN URBAN ENTOMOLOGY

19 May 2008

ARNOLD MALLIS MEMORIAL AWARD LECTURE:

"…BIND THE PAST, DEFINE THE PRESENT, AND PREDICT THE FUTURE…" - A SEQUEL TO *SUBTERRANEAN TERMITES: A PERSONAL PERSPECTIVE* BY J. P. LA FAGE (1986)

Nan-Yao Su
Department of Entomology and Nematology, Fort Lauderdale Research and Education Center,
University of Florida, Davie, FL

During the first National Conference of Urban Entomology held in College Park, MD, the late Jeffery P. La Fage presented a paper entitled, "Subterranean Termites: A Personal Perspective," in which he attempted to "…bind the past, define the present, and predict the future…" of termite research in North America. The current paper is intended as the sequel of La Fage (1986).

It is widely recognized that the foundation of termite research in North America was established with the publication of the "A Revision of the Nearctic Termites" by Banks and Snyder (1920). Two prominent names that followed in the early 1900s were C. A. Kofoid of the University of California at Berkeley, and A. E. Emerson of the University of Chicago. Aside from their personal achievements, their influences are abundantly evident in the research activities of their students and grand-students.

La Fage listed 26 "active" (excluding students and retirees) termite researchers in 1986, which have grown to include at least 52 active termite researchers in 2008. The mean number of termite papers published between 1981 and 1985 was 29 annually, and a brief survey in 2005 accounts for 78 papers in the U.S. The research productivity thus increased from 1.1 to 1.5 papers per year per researcher in the last 20 years.

La Fage (1986) was the first to raise the environmental concerns over the soil termiticide applications near homes and highly populated urban areas. Based on 1% chlordane being applied for a home of 185 m^2, he estimated an insecticide use rate of 390 kg/ha for subterranean termite control, which was approximately 180-fold more than the agricultural rate of 7.25 kg/ha (Pimentel and Levitan 1986). La Fage then predicted that with the development of termite baits, we would use 15,000-time less insecticide than conventional soil termiticides. This prediction, however, turned out to be overly optimistic. Today's soil termiticides are typically used at ≈0.1% (fipronil) to 0.5% (cypermethrin) rates. Because the market shares for non-repellent termiticides and pyrethroids are >50% and 20%, respectively, the AI rate for combined liquid termiticides is estimated at 83.6 kg/ha. This figure is still 1,672-time more than the 0.05 kg/ha of AI use rate for current termite bait products (based on hexaflumuron data). However, termite bait products account for only 20-30% of the market share, and their impacts in pesticide reduction for termite control are not as great as anticipated by La Fage (1986).

References

Banks, N., and T. E. Snyder. 1920. A revision of the Nearctic termites with notes on biology and geographic distribution. U. S. Nat. Mus. Bull. 108. 22 p.

La Fage, J. P. 1986. Subterranean termites: A personal perspective, pp. 45-57. Proc. Nat. Conf. Urban Entomol. College Park, MD.

Pimentel, D., and L. Levitan. 1986. Pesticides: Amounts applied and amounts reaching pests. Bioscience 36: 86-91.

STUDENT SCHOLARSHIP AWARD PRESENTATIONS

19 May 2008

MASTER OF SCIENCE AWARD:

CHANGES IN DIVERSITY: A SUCCESSIONAL STUDY OF THE PEST ANT SPECIES IN PUERTO RICAN HOUSING DEVELOPMENTS

Preston H. Brown
Department of Entomology, Virginia Tech, Blacksburg, VA

Torres and Snelling (1997) completed a comprehensive survey of all ant species in Puerto Rico. Overall, 71 species of ants were identified from the main island and surrounding keys. However, the authors did not specifically identify which species, if any, were collected in urban environments nor did they identify groups of ant species living in the same urban habitat. In general, very few studies have evaluated the community dynamics of pest ant species in urban environments and little is known about how pest ant species interact with each other. For example, which pest ant species are the first invaders into newly disturbed urban habitats and which species dominate the pest ant complex?

To study the pest ant community dynamics in Puerto Rico, three housing developments of different ages (1, 4, and 8 years old) were selected for sampling. Sampling was conducted at 30 houses within each housing development, all of which were located in Santa Isabel. Baits were used to sample for ants around the homes. The baits consisted of cotton rope segments (3.8 cm long) that were saturated in either a sucrose solution (25%) or peanut oil. Each rope segment was placed into a glass vial and three pairs of vials (one sucrose and one peanut oil bait) were placed around the front perimeter of each house. Vials were collected after 1 hour, filled with alcohol, and capped, trapping any ants inside the vial. Over a 2-day period, sampling was conducted within each housing development in the morning and afternoon. Eight trips were made to Puerto Rico over a 1-year period to sample the pest ant species complex. More than 1,000 samples were collected during each trip, and all of the ants in each sample were counted and identified.

The results of the sampling indicated that many different pest ant species co-exist in disturbed urban environments. More than 243,000 ants were collected, and 19 different species of ants were identified, including major pest ant species: *Solenopsis invicta* (red imported fire ants, RIFA), four species of *Pheidole* (big-headed ants), *Paratrechina longicornis* (crazy ants), *Tapinoma melanocephalum* (ghost ants), *Brachymyrmex* spp. (rover ants), and *Monomorium destructor* (destructive trailing ants).

At the 1-year-old housing development, >58,000 ants were collected and 12 species were identified. *S. invicta* was the most abundant species, accounting for 57.4% of all ants collected. *Brachymyrmex sp. 1* was the second most abundant species (19.9% of all ants collected), followed by *Pheidole moerens*

(11.7% of the total number of ants collected). At the 4-year-old housing development, 97,700 ants were collected and 14 species were identified. Again, *S. invicta* was the most abundant species (40.8% of all ants collected). The second and third most abundant species at the 4-year-old site were *Monomorium destructor* (21.1%) and *Pheidole fallax* (14.4%), respectively. Approximately 87,500 ants were collected and 17 species were identified from the 8-year-old housing development. *S. invicta* was the most abundant species collected, accounting for 46.3% of all ants collected from the site. The second most abundant species was *P. fallax* with a relative abundance value of 13.0%. However, there was a large degree of evenness (uniformity of relative abundance values) of the other ant species collected from the 8-year-old site. Nine other species had relative abundance values between 1.0% and 10.0%.

The Shannon diversity index (Molles 2005) was used to measure the ant diversity of each housing development. The diversity index takes into account the species richness and evenness of each site, and increasing the number of species and/or having greater species evenness causes the diversity index to increase. As expected, the 1-year-old site had the lowest diversity index (1.30). The diversity indices of the 4- and 8-year-old sites (1.79 and 1.89, respectively) were determined to be statistically greater than the 1-year-old site. However, the diversity indices of the 4- and 8-year-old sites were not statistically different from each other. We concluded that the 1-year-old housing development was the least diverse site. In addition, although the 8-year-old site had the greatest diversity index, it was not more diverse than the 4-year-old site.

References

Molles, M. C. J. 2005. Ecology: Concepts and Applications. McGraw-Hill, New York, NY.

Torres, J. A., and R. R. Snelling. 1997. Biogeography of Puerto Rican ants: a non-equilibrium case? Biodiversity and Conservation 6: 1103-1121.

PH.D. AWARD:

BED BUG RESEARCH: CATCHING UP WITH A FORGOTTEN PEST

Alvaro Romero
Department of Entomology, University of Kentucky, Lexington, KY

Prior to the mid-twentieth century bed bugs, *Cimex lectularius* L., were fairly common in the USA and other countries (Usinger 1966). However, after the advent of powerful synthetic insecticides such as DDT in the 1940's, their prevalence greatly decreased, particularly in developed countries, and only sporadic infestations were detected, primarily in dwellings with high occupant turnover and questionable sanitation conditions (Krueger 2000). Over the last ten years however, a general global resurgence of bed bugs has been reported in Asia, Europe, North America, and Australia (Krueger 2000; Boase 2001; Doggett et al. 2004). Intense media coverage on bed bugs in recent years reflects the public reaction to an insect that is becoming a major pest throughout the USA (Anderson and Leffler 2008). Further evidence that bed bugs are on the rise was presented in a recent online survey among the pest management industry in which 91% of responders reported having encountered bed bugs during a two-year period (2006-2007) (Potter 2008). Bed bug infestations are now being reported from a variety of locations in the urban environment, including single-family dwellings, apartments, hotels, and health care facilities (Hwang et al. 2005, Potter 2008).

Bed bug infestations can have adverse effects on health and quality of life. The awareness of having being bitten by bed bugs often creates anxiety and sleeplessness in affected people (Hwang et al. 2005). Lesions caused by bed bug bites usually occur on exposed areas of the face, neck, and extremities and commonly appear as small clusters of erythematous papules or wheals (Thomas et al. 2004). The clinical presentation of bed bug bites substantially varies among individuals, depending on the degree of previous exposure (Leverkus et al. 2006). Vigorous scratching and concomitant erosions predispose the skin to secondary bacterial infection (Millikan 1993).

The resurgence of bed bugs raises concerns about the role that these insects play in the epidemiology of many diseases. Several studies have demonstrated that bed bugs carry approximately 20 different pathogens associated with human illnesses, including leishmaniasis, American trypanosomiasis, rickettsia, pasturella, tularemia, yersina, Q fever, plague, relapsing fever, leprosy, oriental sore, and brucellosis (Burton 1963). To date, there is no substantial evidence of transmission of these organisms from bed bugs to humans through bites.

Bed bug infestations often require expensive ongoing inspections and treatments, disposal and replacement of infested beds and other furnishings, and quarantine of infested areas. In public facilities they may result in adverse publicity, and litigation by persons who are bitten (Doggett 2005, Potter 2005). Bed bug infestations are expected to increase in the coming years, presenting many challenges to the pest control industry. Basic and applied knowledge about this urban pest is extremely limited compared to other major pest insects. The scarcity of bed bugs for the last 50 years has created this knowledge gap. The need for new information is supported by the fact that even experienced pest management specialists struggle to bring bed bug populations under control. The research objectives of the author are designed to provide not only practical information for the pest control industry and its stakeholders, but also to begin to resolve the knowledge vacuum that surrounds this pest.

Circadian locomotor activity: Bed bugs are usually described as having nocturnal activity with restricted locomotor activity during daytime. Very little scientific information is available on this matter. Mellanby (1939) observed inactivity during the light period, but an increased activity when the insects were exposed to dark conditions with peaks of activity near dawn. Studies in our laboratory confirm that this periodicity occurs in female and male adults and nymphs, with a marked increase in activity during nighttime. Further experiments are determining whether this periodicity is controlled by endogenous factors, as well as how nutritional status and mating status influence circadian locomotor activity. Similarly, attempts to assess the relative ecological importance of environmental factors such as temperature in locomotor daily rhythm and the role of light as biological clock setters are being conducted.

Aggregation behavior: During daytime, bed bugs are generally found in crevices and cracks, aggregated in clusters, and in contact with their accumulated fecal matter, egg shells, and exuviae. Bed bugs return to aggregations after a blood meal, where they remain inactive while digestion takes places. Little is known about what cues bed bugs use to return to harborages. Marx (1955) suggested that bed bugs are driven by scent gland odors and feces to return to harborages, but he was unable to provide evidence of it. Schildknecht (1964) used chromatography to study the chemical composition of scent gland secretions and identified the compounds Δ^2-*n*-hexenal and Δ^2- *n*-octenal. Collins (1968) reported that, in addition to these compounds, bed bugs produce ethanal and 2-butatone; however their biological importance was not determined. Later studies by Levinson and Bar Ilan (1971) demonstrated that bed bugs aggregate on filter paper impregnated with their body scents and feces. Levinson et al. (1974) subsequently were not able to demonstrate that Δ^2-*n*-hexenal and Δ^2-*n*-octenal played a role in aggregation behavior. Instead, these compounds promoted dispersion in assembled bed bugs, leading the investigators to suggest a role in alarm communication. In our laboratory, we conducted behavioral bioassays by exposing bed bugs to filter paper impregnated with body scents and feces that had accumulated for 48 hours, and we observed that the filter paper elicited aggregation among bed bugs. The goal of our research is to determine the role of bed bug-derived compounds in aggregation behavior.

Insecticide research: Control of bed bugs today is primarily based on intensive application of a limited number of insecticides, mainly pyrethroids and a pyrrole, chlorfenapyr. Although such insecticides are the mainstay of bed bug control today, little is known about their impact on bed bug populations. There is an urgent need for up-to-date information on the efficacy of these insecticides as well as their sublethal effects on bed bugs. We conducted initial insecticide tests using four bed bug populations collected from human dwellings, one from Lexington, KY, and three from Cincinnati, OH. Dose-response analysis showed extremely high levels of resistance to two pyrethroid insecticides, deltamethrin and lambda cyhalothrin. Further evaluations of populations from across the U.S. indicated that resistance to pyrethroid insecticides was widespread (Romero et al. 2007a,b). Chlorfenapyr killed pyrethroid-resistant bed bugs, but the time to obtain >80% mortality varied among bed bug strains, ranging from 6 days to 2 weeks (Romero, unpublished data). The behavioral responses of bed bugs to deltamethrin and chlorfenapyr were also evaluated in the laboratory. In two-choice tests, insects avoided resting on filter paper treated with deltamethrin, but they did not avoid surfaces treated with chlorfenapyr. Avoidance to deltamethrin did not occur when the treated surfaces contained harborage-derived stimuli, i.e., the odors from feces, other bed bugs, eggs, etc. (Romero, unpublished data). Ongoing studies are assessing the impact of insecticides on egg-laying, host-finding, feeding, and harborage-seeking.

References

Anderson, A. L., and K. Leffler. 2008. Bedbug infestations in the news: a picture of an emerging public health problem in the United States. J. Environ. Health 70: 24−27.

Boase, C. J. 2001. Bedbugs – back from the brink. Pestic. Outlook 12:159−162.

Burton, G. J. 1963. Bedbugs in relation to transmission of human disease. Public Health Rep. 78: 513−524.

Collins, R. P. 1968. Carbonyl compounds produced by the bed bug, *Cimex lectularius*. Ann. Entomol. Soc. Am. 61: 1338−1340.

Doggett, S. L. 2005. Bed bug biology and control, pp. 7.1−7.69. *In* S. L. Doggett [ed.]. Pests of Disease and Unease. Westmead Hospital, Sydney, Australia.

Doggett, S. L., M. J. Geary, and R. C. Russell. 2004. The resurgence of bed bugs in Australia: with notes on their ecology and control. Environ. Health 4: 30−38.

Hwang, S. W., T. J. Svoboda, I. J. De Jong, K. J. Kabasele, and E. Gogosis. 2005. Bed bug infestations in an urban environment. Emerg. Infect. Dis. 11: 533−538.

Krueger, L. 2000. Don't get bitten by the resurgence of bed bugs. Pest Control 68: 58−64.

Leverkus, M., R. C. Jochim, S. Schad, E. Brocker, J. F. Andersen, J. G. Valenzuela, and A. Trautmann. 2006. Bullous allergic hypersensitivity to bed bug bites mediated by IgE against salivary nitrophorin. J. Investig. Dermatol. 126: 91−96.

Levinson, H. Z., and A. R. Bar Ilan 1971. Assembling and alerting scents produced by the bedbug *Cimex lectularius*. Experientia 27: 102−103.

Levinson, H. Z., A. R. Levinson, B. Müller, and R. A. Steinbrecht. 1974. Structure of sensilla, olfactory perception and behaviour of the bed bug, *Cimex lectularius*, in response to its alarm pheromone. J. Insect Physiol. 20: 1231-1248.

Marx, R. 1955. Üeber die wirtsfindung und die bedeutung des artspezifischen duftstoffes bei *Cimex lectularius* Linné. Z. Parasitenk. 17: 41–73.

Mellanby, K. 1939. The physiology and activity of the bed bug, (*Cimex lectularius* L.). Parasitology 31: 200−211.

Millikan, L. E. 1993. Papular urticaria. Seminars Dermatol. 2: 53–56.

Potter, M. F. 2005. A bed bug state of mind: emerging issues in bed bug management. Pest Control Technol. 33: 82−85, 88, 90, 92−93, 96−97.

Potter, M. F. 2008. The business of bed bugs. Pest Mangt. Professional 76(1): 28-44.

Romero, A., M. F. Potter; D. Potter, and K. F. Haynes. 2007a. Insecticide resistance in the bed bug: A factor in the pest's sudden resurgence? J. Med. Entomol. 44: 175−178.

Romero, A., M. F. Potter, and K. F. Haynes. 2007b. Insecticide-resistant bed bugs: implications for the industry. Pest Control Technol. 37(7): 42, 44, 46, 48, 50, 143.

Schildknecht, H. 1964. Defensive substances of the arthropods, their isolation and identification. Angewandte Chemie International Edition in English 3: 73−82.

Thomas, I., G. G. Kihiczak, and R. A. Schwartz. 2004. Bedbug bites: a review. Internat. J. Dermatol. 43: 430−433.

Usinger, R. L. 1966. Monograph of Cimicidae (Hemiptera−Heteroptera). Thomas Say Foundation, College Park, MD.

STUDENT PAPER COMPETITION

19 May 2008

EFFICACY OF CHLORPENAPYR-TREATED WOOD TO PREVENT COLONIZATION BY DEALATES OF THE WEST INDIAN DRYWOOD TERMITE, *CRYPTOTERMES BREVIS*

Maria Teresa Ferreira and Rudolf Scheffrahn
University of Florida, Fort Lauderdale Research and Education Center, Davie, FL

Cryptotermes brevis is an important drywood termite pest. Dispersing alates are attracted to light and shed their wings soon after landing on wood. Significantly more nuptial pairs colonized lighted wooden cubes than neighboring unlit cubes. Newly dealated heterosexual pairs commence rapid and vigorous searching for nuptial chamber sites. Based on the observations of this behavior it was hypothesized that searching movements would cause protracted dealate contact with surface deposits of non-repellent insecticides. We applied chlorfenapyr (600 ppm) and fipronil (1250 ppm) to 100, 50, and 12.5% of the surfaces of boards (18.42 by 18.42 cm) and then drilled them with holes to serve as nuptial chamber sites. The boards were exposed to dispersing *C. brevis* alates and mortality was assessed after 7 days. There was a significant increase in mortality with the insecticidal treatments compared to untreated surfaces. Only with whole surface treatments did chlorfenapyr yield significantly lower mortality than fipronil. No chlorfenapyr treatment achieved >50% mortality.

THE POPULATION EXPANSION OF PEST ANT SPECIES IN THE PRESENCE OF *SOLENOPSIS INVICTA* DURING STAGES OF URBAN SUCCESSION

Preston H. Brown, Dini M. Miller, and Carlyle C. Brewster
Department of Entomology, Virginia Tech, Blacksburg, VA

The invasive ant species complex was examined within three Puerto Rican housing developments. Housing developments (1, 4, and 8 years old), located in Santa Isabel were selected to represent different phases of succession (aggradation, transition, and steady state). Frequency and relative abundance data were collected and spatiotemporal analysis mapped the location of each ant species within the housing developments. A total of 19 different ant species were identified from the developments, with the major pest species being red imported fire ants (*Solenopsis invicta*), big-headed ants (*Pheidole* spp.), crazy ants (*Paratrechina longicornis*), and rover ants (*Brachymyrmex* sp. 1). *S. invicta* accounted for over 46% (113,000) of the total ants collected (243,000). In the 1-year-old housing development, *S. invicta* accounted for 57% of all ants collected, yet 11 other species also were present. In the 4-year-old site, 41% of the ants were *S. invicta,* with 13 additional species present. In the 8-year-old site, *S. invicta* accounted for 46% of ants collected, although 16 other species also were present. All ant species, including *S. invicta,* increased both their frequency and abundance during the 1-year research period.

INDOXACARB TOXICOLOGY IN THE GERMAN COCKROACH

Ameya D. Gondhalekar, Cheol Song, and Michael E. Scharf
Entomology and Nematology Department, University of Florida, Gainesville, FL

Advion® gel bait formulation (active ingredient: indoxacarb) recently has been introduced commercially for control of different cockroach species, including the German cockroach (*Blatella germanica* L.). Indoxacarb (DPX-JW062), an oxadiazine insecticide, is a potent sodium channel inhibitor and is known to act as a pro-insecticide (i.e., in the insect body it undergoes bioactivation to a toxic metabolite that is more active than the parent compound). It is known that in lepidopteran larvae, indoxacarb is bioactivated to decarbomethoxyllated JW062 (DCJW) by esterase and/or amidase enzymes. However, very limited information is available on the toxicology of indoxacarb in the German cockroach. Our present studies are aimed at elucidating the mechanisms of activation (esterase and P450 monooxygenases) in the German cockroach. Moreover we will be investigating the effects of indoxacarb and DCJW on the German cockroach central nervous system.

GENE EXPRESSION PROFILES OF *RETICULITERMES FLAVIPES* IN RESPONSE TO SOCIO-ENVIRONMENTAL CONDITIONS

Matthew R. Tarver and Michael E. Scharf
Entomology and Nematology Department, University of Florida, Gainesville, FL

Caste differentiation in social insects is dependent on a number of extrinsic and intrinsic factors. Regulation of caste differentiation is important in maintaining an efficient balance of the number of different castes within a colony. Too many individuals of one caste can have a negative impact on the efficiency of the colony as a whole. A number of different factors have been shown to modulate caste composition in termites. Here, we investigated the impact of JHIII, soldier head extracts (SHE), JHIII + SHE, and live soldiers on gene expression profiles in *Reticulitermes flavipes* workers. Using quantitative real-time PCR (qRT-PCR) we identified a number of genes either upregulated or down regulated in response to different influences. These findings support the idea that soldier termites play a role in regulating worker nestmate caste differentiation and have the potential to lead to new methods for termite control. By understanding the mechanisms of caste regulation it could be possible to disrupt the caste regulation process in termite colonies. Causing the colony to have a disproportional amount of a particular caste would negatively affect the balance of the colony composition and lead to a crash in the colony.

TERMITE-MEDIATED ALTERATION OF FOOD ITEMS

Nicola T. Gallagher and Susan C. Jones
Department of Entomology, Ohio State University, Columbus, OH

Subterranean termites are highly susceptible to desiccation, and moisture is a critical factor in their survival. Consequently, water relations govern many facets of termite biology. Termites possess a pair of salivary reservoirs that function in water storage. This stored water presumably is used to raise the humidity in unfavorable microclimates. The main objective of this research study was to evaluate moisture change of a dry food source (cellulose pad) in the presence of the eastern subterranean

termite, *Reticulitermes flavipes*, during a 21-day period. The test arena was comprised of a chamber with moist sand connected via tygon tubing to a food chamber containing an oven-dried cellulose pad. At each observation period, workers were removed from the sand side and the food side of each arena and micro-dissections were performed to remove their salivary reservoirs. The volume of the workers' salivary reservoirs then was measured.

This study demonstrated that termites rapidly transported water to a dry food source. The average moisture of the food source at the 3-hour observation was ~7%, increasing to a maximum of ~54% at the 21-day observation. Moisture levels continuously increased over time in the presence of termites, and moisture levels were highly correlated with consumption of the cellulose pad. At each observation period, workers removed from the food side had smaller salivary reservoirs compared to those removed from the moist sand side indicating that termites were depositing salivary reservoir contents onto the food; however this difference was significant only at the 3-hour reading. The minimum volume of the salivary reservoirs was approximately 0.2 mm^3 for termites removed at 9 hours from the food side, while the largest volume was approximately 0.8 mm^3 for termites removed at 3 hours from the moist sand side. An understanding of the physiological and behavioral mechanisms involved with water maintenance will provide a framework for manipulating environmental factors critical to termite survival.

EFFICACY OF BROADCAST FORMULATIONS FOR CONTROL OF THE RED IMPORTED FIRE ANT (*SOLENOPSIS INVICTA* BUREN) IN VIRGINIA

Hamilton Allen and Dini M. Miller
Department of Entomology, Virginia Tech, Blacksburg, VA

The red imported fire ant, *Solenopsis invicta* Buren, is a major pest in the southeastern United States because of its ability to spread rapidly and produce painful stings. In recent years the red imported fire ant has emerged as a significant pest in southeast Virginia. Currently, the standard fire ant treatment in Virginia consists of an initial application of hydramethylnon (0.73%) bait followed by an acephate mound drench after 6 weeks. However, several field studies have demonstrated that individual mound treatments are time consuming and not as effective as some of the more novel broadcast methods. In this study the efficacy of three broadcast treatments, indoxacarb (0.45%), fipronil (0.0143%), and a combination of indoxacarb (0.45%) + fipronil (0.0143%) were compared to the hydramethylnon (0.73%) + acephate individual mound treatment. Treatment efficacy was determined by comparing the number of ants foraging on hot dogs prior to and after treatment. Pre-treatment numbers of ants foraging were used as a comparative baseline. Hydramethylnon andindoxacarb applications were both effective, as red imported fire ant foraging activity decreased by 90% at 3 days post-treatment. However, foraging activity increased 1 month after treatment for both formulations—an 80% increase was observed for baits containing hydramethylnon, whereas a 70% increase was observed for the indoxacarb treatment. Acephate was applied to active mounds in the hydramethylnon plots after 6 weeks. Acephate applications did not cause significant decreases or increases in fire ant foraging. Fipronil applications had a delayed effect on fire ant foraging; a 40% reduction in foraging activity was not observed until 90 days after the initial treatment. The fipronil + indoxacarb combination had the best efficacy for control of red imported fire ants. Foraging pressure in plots treated with the fipronil + indoxacarb combination decreased by 99% on day 3. Foraging pressure in these plots continued to be suppressed for 90 days after the initial treatment.

Student Paper Competition Winners

Winners of the 2008 NCUE Student Paper Competition (left to right): Preston H. Brown (Virginia Tech)--2nd place, Matthew R. Tarver (University of Florida)--1st place, and Nicola T. Gallagher (Ohio State University)--3rd place. (Photo courtesy of Brad Harbison, *Pest Control Technology*)

SUBMITTED PAPERS

COCKROACHES & GENERAL PESTS

19 May 2008

FUNCTIONAL STUDIES OF COCKROACH ALLERGENS USING POST-TRANSCRIPTIONAL SILENCING OF ALLERGEN GENES BY RNA INTERFERENCE

Coby Schal, Alonso Suazo, and J. Chad Gore
Department of Entomology, North Carolina State University, Raleigh, NC

German cockroaches produce several protein allergens linked to the development and exacerbation of allergic diseases such as asthma. Bla g 4, a lipocalin, is produced in the accessory reproductive glands (conglobate and apical utricles) of adult male German cockroaches, is packaged into the spermatophore, and transferred to the female during copulation (Fan et al. 2005). A large proportion of Bla g 4 remains in the spermatophore after it is discarded by the female, suggesting that Bla g 4 may be a component of the spermatophore and not of seminal secretions. Nevertheless, its function has yet to be elucidated. Because Bla g 4 is transferred to the female during copulation as a component of the spermatophore, we hypothesized that Bla g 4 has a role in one or more of the cascade of events associated with courtship, mating, and/or neonate development. To address this, we developed and validated an *in vivo* RNA interference approach which showed that injecting dsRNA homologous to Bla g 4 mRNA produces a dose-dependent silencing of the Bla g 4 protein. Post-transcriptional silencing was confirmed by SDS-PAGE and qRT-PCR. Mating assays with RNAi males demonstrated that absence of Bla g 4 had no measurable role in reproductive events. Instead, it appears that Bla g 4, as a component of the spermatophore, may serve as a dietary supplement delivered by males to protein-deficient females during copulation.

Exposure to Bla g 1 is a strong risk factor for sensitivity to German cockroaches (see Gore and Schal 2007), and approximately 30%–77% of cockroach-allergic individuals have detectable IgE antibodies to purified Bla g 1 extract or recombinant protein. Bla g 1 is associated primarily with the cockroach alimentary tract, mainly the midgut, and Northern hybridization of various gut tissues demonstrated that Bla g 1 is produced only by midgut cells (Gore and Schal 2004). Quantitative analyses of Bla g 1 mRNA expression and Bla g 1 protein levels in adult females showed that both are closely modulated in relation to the reproductive cycle of the female cockroach (Gore and Schal 2005), and the central role of food intake was demonstrated experimentally, as starvation arrested both reproduction and the cyclic modulation of gut Bla g 1 levels, whereas re-fed females resumed mRNA expression and Bla g 1 production. Bla g 1 might serve at least two interesting physiological functions, both of which are associated with food intake. It could be secreted into the midgut and serve a role in digestion, or Bla g 1 could serve a structural rather than an enzymatic role in the midgut. We have silenced the expression of Bla g 1 in adult females with dsRNA injection. Feeding was significantly suppressed in treated females, resulting in suppression of juvenile hormone production and therefore slower oocyte maturation. The results indicate that Bla g 1 serves an important function in the processing of nutrients in the cockroach midgut.

Acknowledgments

Supported in part by USDA-RAMP grant #2005-51101-02388, and the Blanton J. Whitmire Endowment at NCSU.

References

Fan, Y., J. C. Gore, K. O. Redding, L. D. Vailes, M. D. Chapman, and C. Schal. 2005. Tissue localization and regulation by juvenile hormone of human allergen Bla g 4 from German cockroach, *Blattella germanica* (L.). Insect Molecular Biology 14: 45–53.

Gore, J. C., and C. Schal. 2004. Gene expression and tissue distribution of the major human allergen Bla g 1 in the German cockroach, *Blattella germanica* L. (Dictyoptera: Blattellidae). Journal of Medical Entomology 41: 953–960.

Gore, J. C., and C. Schal. 2005. Expression, production and excretion of Bla g 1, a major human allergen, in relation to food intake in the German cockroach, *Blattella germanica* (L.). Medical and Veterinary Entomology 19: 127–134.

Gore, J. C., and C. Schal. 2007. Cockroach allergen biology and mitigation in the indoor environment. Annual Reviews of Entomology 52: 439–463.

EFFECT OF SPATIAL COVERAGE WITH INDOXACARB GEL BAIT ON COCKROACH POPULATIONS IN INFESTED APARTMENTS

Coby Schal and Richard G. Santangelo
Department of Entomology, North Carolina State University, Raleigh, NC

German cockroach allergens have been linked to the development and exacerbation of asthma in cockroach-sensitive individuals (Gore and Schal 2007). We recently showed that an intensive and targeted cockroach management program alone can reduce cockroach allergens below proposed exposure thresholds (Arbes et al. 2003, 2004). These studies clearly demonstrated the efficacy of gel baits in suppressing cockroach populations and reducing cockroach allergens.

In 2007 we reported on an evaluation of the effectiveness of cockroach control by comparing the effectiveness of pest control performed by professional entomologists (NCSU) with pest management service companies (Sever et al. 2007). Homes treated by professional entomologists experienced significant reductions in both cockroach trap catch and allergen concentrations, compared with control homes and homes treated by pest management professionals (PMPs). PMP-treated homes showed no significant allergen reductions at 12 months compared to control homes. Thus, although suppression of cockroach populations can significantly reduce both Bla g 1 and Bla g 2 allergens in cockroach-infested homes, the magnitude of allergen reduction was dependent on the thoroughness and effectiveness of cockroach eradication efforts (Sever et al. 2007).

The differences between our treatments and the services of contracted PMPs might be related to economic and technical considerations. Technical differences between the two treatment regimes included the use of monitoring-based decision making, frequency of service, tactics employed (e.g., baits, sprays), and the spatial coverage of the treatments. PMPs generally targeted the kitchen and bathroom only, while our bait treatments included the whole home.

We now report a comparison of 0.6% indoxacarb gel bait (Advion®) treatment of the whole home versus treatment of the kitchen and bathroom only. As expected, we found no differences between the two treatment regimes in the magnitude of cockroach reduction in the kitchen and bathroom, and both were significantly different from untreated control apartments. However, large and highly significant differences were found in suppression of cockroaches in the living rooms and bedrooms. The whole home treatments with Advion® were highly effective, reducing trap catch rapidly within 7 – 14 days. Conversely, it took 90 days for the kitchen and bathroom-only treatments with Advion® to control cockroaches in the living room, and acceptable cockroach control was not achieved in the bedroom at the conclusion of this 90-day study.

These results demonstrate that while significant reductions in indoor environmental cockroach allergens can be achieved by cockroach control alone, the magnitude of these reductions depends upon several factors, including technical expertise, the intensity and quality of the service, and the products used for cockroach control. The spatial distribution of gel baits throughout the home appears to be a key factor in cockroach control, probably because of limited movement of cockroaches between rooms, and limited horizontal transfer of baits between rooms. Therefore, gel baits need to be delivered where cockroaches aggregate, and this is particularly important in bedrooms, where cockroach-sensitive individuals spend the majority of their time, potentially in close proximity to cockroach allergens.

Acknowledgments

Supported in part by a grant from DuPont, and the Blanton J. Whitmire Endowment at NCSU.

References

Arbes, S. J., M. Sever, J. Archer, E. H. Long, J. C. Gore, C. Schal, M. Walter, B. Nuebler, B. Vaughn, H. Mitchell, E. Liu, N. Collette, P. Adler, and D. C. Zeldin. 2003. Abatement of cockroach allergen (Bla g 1) in low-income, urban housing–a randomized controlled trial. Journal of Allergy and Clinical Immunology 112: 339–345.

Arbes, S. J., M. Sever, J. Mehta, J. C. Gore, C. Schal, B. Vaughn, H. Mitchell, and D. C. Zeldin. 2004. Abatement of cockroach allergens (Bla g 1 and Bla g 2) in low-income, urban housing: Month 12 continuation results. Journal of Allergy and Clinical Immunology 113: 109–114.

Gore, J. C., and C. Schal. 2007. Cockroach allergen biology and mitigation in the indoor environment. Annual Reviews of Entomology 52: 439–463.

Sever, M. L., S. J. Arbes , J. C. Gore, R. G. Santangelo, B. Vaughn, H. Mitchell, C. Schal, and D. C. Zeldin. 2007. Cockroach allergen reduction by cockroach control alone in low-income, urban homes: A randomized control trial. Journal of Allergy and Clinical Immunology 120: 849–855.

EFFECTIVE COCKROACH MANAGEMENT IN PROBLEM ACCOUNTS USING MAXFORCE® FC MAGNUM COCKROACH BAIT GEL: FIELD AND LABORATORY PERSPECTIVES

Nonggang Bao, Deborah Koufas, Gary Braness, Joe Barile, Joe Hope, and John Paige
Bayer Environmental Science, Research Triangle Park, NC

Maxforce® FC Magnum Cockroach Bait Gel (0.05% fipronil) is the newest commercial cockroach gel bait introduced to meet the needs of pest management professionals (PMPs) for effective cockroach control. PMPs reported increased incidences of control failures using the current commercial cockroach baits. This paper summarizes laboratory studies against bait-averse German cockroach, *Blattella germanica*, strains collected from problem accounts across the country, and field studies with PMPs at residential and commercial accounts in five states.

Laboratory studies confirmed that the current commercial gel baits have become less effective against bait-averse strains of the German cockroach due to new mechanisms of bait aversion, with the conclusion that a simple rotation of the commercially available gel baits would not help solve the control issues. Based on comparative studies of several commercial gel baits, it was determined that a palatable bait that integrates speed of kill, secondary kill, and contact kill would achieve the most effective control of these finicky eaters.

Several field studies were conducted jointly with local PMPs in seven residential and commercial accounts, including apartments and commercial establishments, in five states: CA, FL, MO, NC, and NY. Maxforce® FC Magnum provided a mean of 89.7% population reduction in German cockroaches within 2 days after application, and a mean of 98.6% population reduction at 30 days after treatment. Note that the majority of these accounts were categorized as severe “problem accounts” where previous treatments with commercial baits had failed to control the bait-averse German cockroaches.

TRANSPORT® GHP INSECTICIDE: A NEW TOOL IN THE BOX FOR GENERAL HOUSEHOLD PEST CONTROL

Dina L. Richman and Jim Walter
FMC Corporation, Philadelphia, PA

Transport® GHP Insecticide is a new product from FMC Corp. for control of insect pests. It is non-repellent mixture of bifenthrin and acetamiprid contained in two formulation versions: a wettable powder in water soluble bags and a novel micro-emulsion technology. Both formulations have shown equal to better efficacy performance versus competitors. Additionally, the unique combination of these active ingredients is a potential risk management tool for end-users.

FACTORS INFLUENCING REFUGIA PREFERENCES BY THE RECLUSE SPIDERS *LOXOSCELES RECLUSA* AND *LOXOSCELES LAETA*

Richard S. Vetter and Michael K. Rust
Department of Entomology, University of California, Riverside, CA

At the 2006 NCUE meeting in North Carolina, we presented information regarding refugia preferences of the brown recluse spider, *Loxosceles reclusa*, and a South American recluse spider, *L. laeta* (Vetter and Rust 2008). These experiments were conducted with the expectation of developing a pest control device, which might attract recluse spiders and eliminate them from a structure.

Briefly, the results reported by Vetter and Rust (2008) are summarized here. Both *Loxosceles* species preferred crevices in cardboard refugia (25 mm x 25 mm with an additional overhang of 25 mm on one length) that were vertically rather than horizontally oriented. When given refugia with varying crevice widths (3 to 21 mm), there was no correlation between the size of the spider and the crevice that it preferentially sought to hide in during the day; as long as a *Loxosceles* spider could fit its body into a crevice, this was sufficient. Nonetheless, small spiders just as readily chose the largest crevice widths as the smallest crevice widths. Therefore, manufacture of a control device should not be limited by construction logistics. We also conducted a 30-day experiment to test site fidelity by offering four equal-sized refugia to spiders, and we observed that some spiders were only found in the same crevice each morning whereas others moved around on the average of every 2 to 3 days. Therefore, many spiders do move around such that they might enter an insecticide-contaminated station. When offered a choice between a crevice that was new or one that had silk deposited from a conspecific during the 30-day tests, both *Loxosceles* species overwhelmingly chose the refugia covered with silk. Therefore, silk might be a worthy item to incorporate into a control device design.

This research (Vetter and Rust 2008) spawned additional studies where we investigated some of the factors that might make the silk attractive to *L. reclusa* and *L. laeta.* Note that the following information represents very preliminary results from several experiments, and additional research is planned.

In the first experiment, when offered a choice between silk-covered refugia of their own species and that of a congeneric, both *L. reclusa* and *L. laeta* showed no statistically significant preferences for either species' silk. Although there was a trend for both species to choose *L. laeta* refugia more often, this may have been due in part to the fact that *L. laeta* deposits more silk than does *L. reclusa*. These results indicate that spider preference for silk-covered refugia is not limited to its own species and, hence, if a control device can be developed, it may be useful for any *Loxosceles* population.

The second experiment tested whether *L. laeta* preferred recently inhabited refugia compared to similar refugia that were heated and aged for 2 weeks. This study was conducted only with *L. laeta* due to logistical problems. An equal number of male and female spiders were chosen as silk donors and placed in new refugia for 2 weeks. These silk donors deposited silk on the refugia, in the crevice, and across the opening. After 2 weeks, they were gently forced out of the refugia and offered another set of new refugia for 2 weeks. The first batch of refugia were separated by sex of the occupant and heated for 4 days at 60º C. After the silk donors had occupied the second set of refugia for 2 weeks, they were forced out again. Plastic arenas were set up where a second set of spiders (each replicate consisting of 6 males, 6 females and 6 immatures) were individually offered the choice of two refugia from the same silk donor to minimize variation. The refugia choices consisted of one where the occupant had been forced out earlier in the day and the other that was aged for 2 weeks and heated. At the time of abstract submission, three replicates were run with plans for an additional three assays. The results so far showed no clear preference for either type of refugium overall and neither sex of the silk donor nor sex/maturity status of the choosing spider had an effect on the choice of fresh vs. aged, heated refugia. Assuming that the heating and aging had some effect on the chemical odors of the silk, the conclusion from this experiment is that physical aspects of the silk might be much more important than chemical cues.

A third experiment examined whether *L. reclusa* and *L. laeta* discriminated between refugia of a conspecific versus a distantly related cribellate spider (*Metaltella simoni* [Amphinectidae]). Although recluse spiders are ecribellates, their silk shares many similarities to cribellate silk, i.e., dry silk that catches prey via entanglement of tarsi (similar to velcro adhesion) rather than with sticky adhesive. In this study, *M. simoni* were placed in vials with new refugia for 2 weeks, then forced from the refugia. *Loxosceles* spiders were placed in an arena with two refugia: one from the freshly evicted *M. simoni* and one from a conspecific from a previous experiment. Both *Loxosceles* species overwhelmingly chose refugia that had previously housed a conspecific although a small minority chose the *Metaltella*-occupied refugium.

To summarize, for the *Loxosceles* species that were tested, there appears to be no specificity for silk of their own species compared to the congeneric, and the heating (60º C) and aging (2 weeks) of silk does nothing to influence preference over fresh silk. Furthermore, *Loxosceles* spiders can readily differentiate between silk of a conspecific and that of a distantly related cribellate spider. Additional experiments are planned to investigate whether there are chemical factors (tactile, low volatility) that might play a role in this silk attraction or whether the physical nature of the silk is sufficient.

References

Vetter, R. S., and M. K. Rust. 2008. Refugia preferences by the spiders *Loxosceles reclusa* and *Loxosceles laeta* (Araneae: Sicariidae). J. Med. Entomol. 45: 36-41.

RESIDUAL EFFICACY OF MAXFORCE® FLY SPOT BAIT (IMIDACLOPRID 10 WG)

Deborah Koufas, Nonggang Bao, John Paige, Gary Braness, Joe Barile, and Vince Parman
Bayer Environmental Science, Research Triangle Park, NC

Maxforce® Fly Spot Bait (imidacloprid 10% wettable granule) is a sprayable bait for controlling the house fly, *Musca domestica*; it is labeled for outdoor residential use and indoor use in non-food/feed areas of commercial facilities. Indoor residual efficacy was evaluated using treated targets. Spray-on and brush-on applications of Maxforce® Fly Spot Bait were made to laminated yellow cards (targets) and aged under indoor conditions. House flies were exposed to treated targets at 0, 1, 2 and 4 weeks after the initial application of Maxforce Fly Spot Bait using two treatment methods: repeated exposure on the same aged targets up to 4 weeks and single exposure on aged targets up to 8 weeks. For outdoor efficacy, spray applications of Maxforce® Fly Spot Bait were made to 'spots' where flies rest around restaurants, livestock areas, dumpsters, and trash areas. In all cases, Maxforce® Fly Spot Bait provided quick knockdown and effective residual control of house flies.

EXEMPT PRODUCTS FOR THE PROFESSIONAL PEST CONTROL MARKET: FADS OR THE FUTURE?

Steve Sims
Whitmire Micro-Gen, St. Louis, MO

Section 25b pesticides are a group of active ingredients that the U.S. Environmental Protection Agency (EPA) has judged to be of “minimum risk” and therefore exempt from the normal requirements of pesticide registration. The 25b list includes materials that are widely used and available (especially food ingredients) and that have a number of characteristics, including a non-toxic mode of action, ‘generally regarded as safe’ (GRAS) status (FDA), no significant adverse effects, low exposure to applicator/non-targets, and short environmental persistence. Producers of 25b pesticides also must meet state registration and regulatory requirements. Individual states have unique pesticide registration and regulation statutes, and the states are not required to permit the sale of an exempted product simply because it meets the EPA’s 40 CFR 152.25(g) conditions for minimum risk exemption (www.epa.gov/oppbppd1/biopesticides/ regtools/25b_list.htm). Efficacy data are required by several states, including Colorado, Indiana, Kentucky, New Mexico, and Mississippi.

Complete list of 25b active ingredients (an asterisk denotes botanically-derived essential oils):

- Castor Oil (U.S.P. or equivalent)
- Cedar Oil*
- Cinnamon* and Cinnamon Oil*
- Citric Acid
- Citronella* and Citronella Oil*
- Cloves* and Clove Oil*
- Corn Gluten Meal
- Corn Oil
- Cottonseed Oil
- Dried Blood
- Eugenol*
- Garlic* and Garlic Oil*
- Geraniol*
- Geranium Oil*
- Lauryl Sulfate
- Lemon Grass Oil*
- Linseed Oil
- Malic Acid
- Mint* and Mint Oil*
- Peppermint* and Peppermint Oil*
- 2-Phenethyl Propionate*
- Potassium Sorbate
- Putrescent Whole Egg Solids
- Rosemary* and Rosemary Oil*
- Sesame (incl. ground sesame plant stalks)
- Sodium Chloride (common salt)
- Sodium Lauryl Sulfate
- Soybean Oil
- Thyme* and Thyme Oil*
- White Pepper*
- Zinc Metal Strips (solely zinc metal and impurities)

Of the 31 active ingredients that are categorized as Section 25b pesticides, 15 are botanically-derived essential oils such as terpenes. Several (5/31) are plant oils such as castor, corn, cottonseed, linseed and soybean.

Exempt pesticides can contain only active ingredients on the EPA 25b list combined with 'other' (inert) ingredients on the EPA 4A list. The EPA 4A inert ingredients are divided into a “Food Use List” and a “Non-Food Use List” (/www.epa.gov/opprd001/inerts/section25b_inerts.pdf). The EPA can change the lists at any time, reflecting the Agency’s updated views on ingredient safety, and it last did so in December 2007.

Section 25b exempt products can have significant activity as contact sprays. They also have fumigant and repellent activity. Several modes of action have been documented. These include action on the G protein coupled receptors (tyramine and octopamine) and a neurotoxic mode of action on the GABA-gated chloride channel and acetylcholinesterase inhibition. They may also act to disrupt cellular membranes.

There are several issues involved with these products that may hinder their development and widespread acceptance. One issue with 25b ingredients is that they have a pungent odor that, combined with high vapor pressure, can lead to applicator and customer irritation. Unfortunately, the odor intensity of the essential oils seems to be positively correlated with the level of biological activity. Essential oils are usually a mixture of many components (for example, rosemary oil can have >200 components) making quality control difficult. Plant extracts are expensive and usually limited in supply. Additionally, relatively large amounts of essential oils are needed to be effective – the most active essential oils on the 25b list are three orders of magnitude less active than pyrethrum.

Granular 25b products, in particular, appear to be significantly less effective than label and marketing claims would suggest. These products may be repellent to target insects, but there is little contact kill activity. This could be a result of the plant oils being bound to the granule and less available. Furthermore, it has been demonstrated that the high volatility of active ingredients results in rapid loss of activity of granular formulations.

TEACHING SYMPOSIUM

GETTING STUDENTS HOOKED ON BUGS

19 May 2008

Organizers:
Dini M. Miller (Virginia Tech University) and Eric Benson (Clemson University)

"BUG" STUDENTS OF ALL AGES

Susan C. Jones
Department of Entomology, Ohio State University, Columbus, OH

Extension entomologists have many opportunities to educate students, whether in a university setting, in elementary or secondary school classrooms, in the community, or in nontraditional teaching environments. Although some segments of the population may not share our fascination with insects, positive or negative comments about insects can provide for a diversity of "teachable moments." Whether one is trying to avoid bee stings or manage a cockroach infestation, I try to convey the message that "knowledge is power."

When giving classroom lectures, I have found that students respond very positively to lessons that I personalize by discussing some of my on-going research projects, unusual laboratory or field experiences, or published manuscripts. I have engaged elementary school students in entomology in numerous ways, such as providing beetle or butterfly larvae to rear, bringing insect collections to view, providing observation termite colonies for their classroom, explaining why termite bait stations have been placed at their school, handing out head lice awareness stickers, etc.

Matthews et al. (1997) have reviewed the printed North American literature and identified exemplary resources for teachers and students, including information on rearing insects. These educators highlight favorite classroom arthropods, which include butterflies and moths, lady beetles, mealworms, fruit flies, honey bees, ants, crickets, and mantises. In my experience, termites are another classroom favorite. I routinely provide subterranean termites for teachers, zoos, and exhibits. The students seem particularly interested in learning about the symbiotic protozoa that inhabit the termite hindgut, social organization, physical and behavioral differences among castes, soil movement by termites, and pheromones. Students of all ages are intrigued to observe termites closely following along newly drawn lines of ink from certain pens (Becker and Mannesmann 1968) -- a classic demonstration of termite trail-following behavior in response to chemical cues (Esenther et al. 1961).

Members of my OSU laboratory also have been involved in entomological events for Science Olympiad, a nonprofit nationwide program that offers team science and technology competitions for students in grades K-3, 3-6, 6-9, and 9-12 (www.soinc.org). The goals of Science Olympiad are to improve the quality of science education, increase student interest in science, and recognize outstanding achievement in science education. Science Olympiad events encompass various science disciplines, including biology, earth science, chemistry, physics, computers, and technology. Science Olympiad strives for a balance among events requiring knowledge of science facts, concepts, processes, skills, and application. Currently, 45 states plus Ontario, Canada are involved in the Science Olympiad program.

References

Becker, G. and R. Mannesmann. 1968. Untersuchungen uber das Verhalten von Termiten gegenuber einigen spurbildenen Stoffen. Z. angew. Entomol. 62: 399-436.

Esenther, G. R., T. C. Allen, J. E. Casida, and R. D. Shenefelt. 1961. Termite attractant from fungus-infected wood. Science 134: 50.

Matthews, R. W., L. R. Flage, and J. R. Matthews. 1997. Insects as teaching tools in primary and secondary education. Annu. Rev. Entomol. 42: 269-289.

NO TERMITE LEFT BEHIND: MEETING BENCHMARKS WITH INSECT SCIENCE

J. Kenneth Grace[1], Erin Baumgartner[2], Julian R. Yates III[1], and Maria Aihara-Sasaki[1]
[1]Dept. of Plant and Environmental Protection Sciences,
University of Hawaii at Manoa, Honolulu, HI
[2]Curriculum Research and Development Group, College of Education,
University of Hawaii at Manoa, Honolulu, HI

In the United States, scientific literacy is recognized as a necessity not only for students destined for a career in research, but more broadly for all citizens in order to address the problems of day-to-day life (AAAS 1990). Understanding the scientific process and the nature of the world around us helps us to make informed decisions in all walks of life (Barab and Leuhmann 2002).

Scientific experiences included as part of the school curriculum help students transfer knowledge gained in class to real-world situations. Student engagement in local- or personal- based problems also engage student interest (Barell 2003). Providing students with authentic, place-based problems also represents the practice of science more completely, particularly as it relates to issues of immediate concern to most people. One such issue is the maintenance and upkeep of personal property against natural forces, including destructive subterranean termites.

In 2003, we initiated a program called “Educate to Eradicate” in public schools and communities throughout the state of Hawaii (Grace et al. 2007). This program combines research, education, and public extension seminars, with the dual goals of (1) suppressing subterranean termite populations and damage by increasing public awareness and implementation of preventative measures, and (2) increasing the scientific literacy (and termite awareness) of tomorrow’s citizens and homeowners. To date, the curriculum developed in this program has been adopted in 191 classrooms in 37 schools on the islands of Oahu, Maui, and Hawaii; with nearly 6,000 students participating in the project.

Students participating in the project learn about classification and identification of insects, termite biology and life cycles, economic impacts and control efforts aimed at pests, and the nature of scientific investigation through a series of inquiry-based lessons that culminate in home inspection activities and public awareness projects that allow students to disseminate what they have learned to their families and communities. The lessons and the materials that we provide to teachers also facilitate relationships to other subject matter and curricular goals. For example, a lesson about social organization of the termite colony and the duties of each caste also allows the teacher to address the broader concept of interdependence. Teachers and students are also encouraged to take ownership of the curriculum through individual modifications and creative (and often humorous) projects.

Our curricula are based on the Hawaii Content and Performance Standards III (HCPSIII), and address benchmarks for each grade level (K-12). In a standards-based system of education, attention to benchmarks is critical to adoption. The lessons provided are inquiry-based, emphasizing self-discovery and construction of knowledge by the students. In a practical sense, the students thus not only become more aware of termites as significant pests, but as better observers and evaluators of information, they are themselves more capable of noticing termites and evaluating how to manage the situation. Such knowledge and skills are transferable to other challenges of life.

The Termite Jar lesson, in which students are presented with a jar containing damp sand, a cut piece of wood, and termites, is an example of a lesson that combines authentic scientific research and inquiry-driven instructional strategy. The activity is meant to incite interest in termites, introduce students to some of their visible behaviors and get students familiar with the first steps of scientific exploration, observation and questioning. This lesson builds content and skills knowledge about termites in students, who also gain scientific experience when they carry out the inquiry-based lesson. The authentic problem of the termite jar is grounded in ongoing research in university and industry laboratories, and is based on nationally-established research methods (AWPA 2006). The investigation of wood preference of termites has real world implications for the building industry, homebuyers and consumers of wood products. While supporting increased knowledge about and awareness of termites, the termite jar project also emphasizes scientific skills like observation, questioning and data collection and analysis. The value of systematic observation, organized data collection, and formulation of a hypothesis containing both a thoughtful prediction and a feasible explanation are part of the lesson.

This lesson is adaptable to a range of grade levels and aligned to national standards at each. Elementary students focus on observation and asking simple questions based on those observations. These questions can be used to design a simple termite investigation. Middle school students focus on the mental skills scientists use when they design an investigation based on their questions, focusing on topics like objectivity, replication, and careful collection of data. High school students engage in a full-scale investigation of wood consumption based on experiments conducted by University of Hawaii researchers.

The lesson is part of a larger sequence designed to increase student and parent (1) knowledge about termites, and (2) ability to apply scientific methods of thinking to protecting their home from termite attack. Students do not require any prior knowledge to conduct the activities, but through observation and questioning, they gain awareness and interest about the larger topics connected to their termite experiment such as plant-animal interactions, insect biology and behavior, and how to ask and answer scientific questions. The inspection survey that is the capstone of the program encourages students and their families to make the same kinds of observations employed in the termite jar experiment with respect to their home and surroundings. These observations employ the process and content knowledge gained by the students to solve real-life problems, truly demonstrating scientific literacy.

Acknowledgments

We are grateful to the Hawaii Department of Education, and the principals and teachers of our partner schools for their cooperation and participation in the project. Funding was provided by USDA-ARS Specific Cooperative Agreement 58-6435-3-087, and by Extension Project 16-902 of the College of Tropical Agriculture and Human Resources.

References

American Association for the Advancement of Science. 1990. Science For All Americans. Oxford University Press, New York, NY.

American Wood-Preservers' Association. 2005. E1-97: Standard method for laboratory evaluation to determine resistance to subterranean termites. AWPA Book of Standards, pp. 287-289.

Barab, S. A. and A. L. Luehmann. 2003. Building sustainable science curriculum: Acknowledging and accommodating local adaptation, Science Education 87(4): 454-467.

Barell, J. 2003. Developing More Curious Minds. Association for Supervision and Curriculum Development, Alexandria, VA.

Grace, J. K., J. R. Yates III, M. Aihara-Sasaki, and G. Lillich. 2007. Community education for better termite control in Hawaii. Proc. Hawaiian Entomol. Soc. 39: 139-142.

EXCITING UNDERGRADUATES WITH SIX-LEGGED SCIENCE

Eric P. Benson and Patricia A. Zungoli
Department of Entomology, Soils and Plant Sciences, Clemson University, SC

In the last ten years, the number of entomologists at Clemson University has decreased, mostly due to positions not being refilled after faculty retirements. Many of the most recent retirements have been teaching faculty with agricultural backgrounds. This created a void and a need for other entomologists at Clemson to add teaching to their appointments or increase their teaching loads. At Clemson, the general entomology course for non-majors (ENT 200: Six-Legged Science) and the general entomology course for biology majors and related sciences (ENT 301: Insect Biology and Diversity) are taught by Urban Entomologists with significant research and Extension appointments. A positive outcome of this situation has been the ability to share Urban Entomology research and Extension experiences with undergraduate students. If students have prior experience with insects, it is often with insects associated with the urban environment, an environment they know well. Urban Entomology provides a wealth of examples on which an instructor can build a foundation for student understanding of basic biological principles.

Since students already have a frame of reference, they learn more easily and can acquire information they can use in the future. In the classroom, many insect examples of morphology, ecology, reproduction, development and behavior can be illustrated with insects common and familiar in the urban environment. For example, silverfish, cockroaches and house flies can be used to discuss different forms of simple to complete metamorphosis. Termites, ants, and bees can be used to discuss eusociality. Cockroaches and grasshoppers are excellent models to explore typical insect external morphology and internal anatomy.

Of the many laboratory demonstrations and exercises, one ENT 301 lab session uses Ebeling choice boxes to evaluate American cockroach feeding preferences and efficacy of common cockroach baits. In addition to teaching the students about a basic Urban Entomology research technique, the combined results of the choice box study have been used for demonstration research examples in Extension presentations to aid in recommendations to clients for bait selection and control of American cockroaches.

Insect collecting trips include a visit to Clemson's off-campus Urban Entomology research laboratory. After collecting in the field, undergraduates are given a tour of the lab where they can observe current Urban Entomology research projects. At the end of the semester, good quality insect collections have been donated to new county Extension agents with responsibilities to support homeowners, local schools, and civic groups with information about insects. The collections of many familiar urban insects help facilitate information transfer about pertinent urban insects and related arthropods.

During the period that general entomology courses at Clemson have been taught by Urban Entomologists, 16 undergraduate students have become lab workers in the Urban Entomology Program. Six of the 16 undergraduates entered graduate programs in Urban Entomology and 12 were ultimately employed in Urban Entomology or related fields.

Acknowledgments

We appreciate the support of laboratory and teaching assistants, especially Theresa Pizzuto, Sonya Prosser, Christy Jo Geraci, and Richard Reeves. This publication is Technical Contribution No. 5507 of the Clemson University Experiment Station.

JUNIOR PEST INVESTIGATORS: TEACHING ENTOMOLOGY AND IPM, KINDERGARTEN TO THE EIGHTH GRADE

Patrick T. Copps
Orkin, Inc., Riverside, CA

Junior Pest Investigators, www.juniorpi.com, was developed by Orkin® to stimulate interest in entomology and integrated pest management (IPM). The program was designed as a four-lesson unit for science classes with each lesson building a knowledge base that contributes to an understanding of pests and effective low risk IPM strategies. This process begins with "Eekology", an introduction to insects and other critters that are potential pests, followed by considerations on what are pests, their needs to ensure survival, and the implementation of common sense IPM techniques. Students are encouraged to participate in "pest investigations" in and around their homes and schools. The information collected during these investigations is used to direct class projects and research and involves parental participation. Teachers take on the role of facilitator or co-investigator by introducing topics, coordinating learning activities, and directing students to resources for further study. The lesson plans, created by a group of professional educational writers, were reviewed by Extension entomologists and are consistent with national science standards.

WHY EVERY ENTOMOLOGIST SHOULD STUDY URBAN ENTOMOLOGY

Dini M. Miller
Department of Entomology, Virginia Tech, Blacksburg, VA

Why should every entomologist study urban entomology? Because the majority of United States citizens now live in urban communities where they have little exposure to animals other than their domesticated pets. Nonetheless, insects are one animal that urban dwellers tend to see every day. People typically know very little about insects other than they don't like them. In fact most people tend to regard insects with fear. Yet, if you engage people in a conversation about insects for more than a few minutes, you typically find that they have many questions and a high level of interest, particularly regarding those insects that directly impact their lives. Unfortunately, the pest control operator is often the closest thing to a field biologist that most people will ever see. However, pest control operators can be an excellent resource for urban citizens if they are properly trained and have a good working knowledge of the biology and behavior of the insects they are attempting to control. But who trains these field biologists, and do we have enough trainers available to cope with the growing population of urban dwellers?

Virginia Tech is a land grant university and one of the few that still has an autonomous Department of Entomology. Urban entomology is offered as one-half of a graduate course titled "Urban and Public Health Entomology". This course is offered every other year. The course focuses on providing students with hands-on experience in dealing with urban pests. Course activities include inspecting a crawl space for signs of termite activity, testing bed bug populations for resistance, and visiting the National Zoo to see and hear what it takes to implement an IPM program in a high profile national landmark. The course culminates in students developing their own IPM program for a sensitive environment.

In spite of the fact that when Virginia citizens call the Department of Entomology it is almost exclusively in regard to an urban pest problem, it is still difficult to convince students that they need to learn about urban pests even though their research focus is agricultural production. As an urban entomologist I try to impress upon students that if one of their family members were to call with a termite or ant problem they would expect their student (with a degree in Entomology from Virginia Tech) to be able to answer their pest question. Why should students study urban entomology? If for no other reason, they should do it to help their friends and family.

In Virginia, the state population in 2007 was 7,712,000:

- 86% (6.6 million) live in urban communities
- 89% of all jobs are in urban locations
- 13.3% of population in farm-related jobs, both urban and rural (mostly broiler chickens)

Is the Virginia Tech Department of Entomology meeting the needs of the urban population? Our department has 20 entomology faculty in the following focus areas:

- 7 agricultural commodities
- 5 molecular/medical entomologists
- 2 forestry and biological control
- 2 ecologists
- 1 physiologist
- 1 pesticide programs

– 1 landscape/nursery
– 1 urban pest management specialist (70% extension, 20% research, 10% teaching)
– No county agents with urban or structural pest expertise in Virginia

Yet, our Department 2008 CSREES review stated the following: “The department as a whole is positioned to take advantage of the changing opportunities and research needs associated with a growing urbanization in Virginia. …The department has developed a research focus that will only increase in importance as Virginia’s urban population increases. This is especially important because there are only a few active urban pest management research programs giving Virginia Tech entomology a competitive advantage in the funding arena and in attracting graduate students”.

If Virginia Tech is positioned to meet the research needs associated with growing urbanization, then we should all be concerned for the future. The one, two, or even four urban entomologists per state are not enough to deal with all the urban insect research or pest management training that is needed. Every entomologist needs to study urban entomology because people need your help.

URBAN ENTOMOLOGY: THE FUTURE OF THE SCIENCE

Roger E. Gold
Department of Entomology, Texas A&M University, College Station, TX

Texas A&M University houses one of the largest Departments of Entomology in the United States. We currently have approximately 95 undergraduate majors, 45 double majors, 10 minors, and 50 graduate students. The faculty has worked diligently to recruit students to the entomology major, including contacting high schools and community colleges, as well as hiring a full time recruiter (Senior Academic Advisor). The result has been an increasing enrollment over the past few years.

We, like many other Departments of Entomology, have faced the possibility of losing our identity by being combined with related sciences, but, to date, we have been able to demonstrate the need for a recognized department. What has been interesting, based on the demographics of the incoming students, is that the majority of students admitted to Texas A&M University do not come from rural backgrounds, even though we are the Land Grant institution for Texas. Those attracted to entomology are primarily urban, coming from the larger cities in Texas. Those graduating from the Department of Entomology are seeking employment that does not necessarily include a direct agricultural emphasis. When we looked at where our undergraduates go following graduation, more than 50% go on to graduate programs either here in Texas or elsewhere. The others find employment in various sectors, including urban programs and the military.

Academic faculty of the Entomology Department have faced some challenges including the need to increase the number of undergraduate majors and to generate more student credit hours for entomology courses, while teaching classes mainly comprised of students who lack both a rural background and science training. Examples that have traditionally been used in discussing insect population management have focused on agricultural pests, but that approach has had to change to reflect a more urban and industrial bent. Another challenge in teaching larger classes in entomology has been to have the time, space, and resources to best involve the students in the learning and retention processes. As a department, there has been a movement away from requiring laboratory sections with many classes. There are many reasons for this, but primarily it is due to the lack of laboratory space, finances to cover the costs of supplies, materials and teaching assistants, and the desire of the faculty to put in the time and energy to plan and conduct laboratory sessions. Unfortunately, many students avoid science classes with a laboratory section due to the three-hour requirement for one hour of credit, and the costs of laboratory fees charged in addition to the general tuition.

Despite these challenges, the interest in urban entomology has steadily increased through time. We have seen the class sizes increase from 14 students 16 years ago, to 42 presently enrolled in Urban Entomology (Entomology 403). While Urban Entomology has been taught for many years, it was a 4-hr credit course from 1990-1994. The department then made a decision to offer a team- taught course, listed as Urban & Medical Entomology (Entomology 426) in 1996, and it was required of all undergraduate majors. The combined format was continued until 2002 when Urban Entomology (Entomology 403) was once again offered; however, the credits were dropped to 3 units, and there were two lectures and a required 3 hour laboratory taught each week.

One of the reasons for the increased enrollment (42 students in 2008) in Urban Entomology is due to the newly created Forensic and Investigatory Science major, administered by the Department of Entomology. These undergraduate students are encouraged to take courses in entomology, even though most have no background in this science. The other indicator of the increasing interest in urban entomology is reflected in how the majors are completing the internships or research options required of all graduating entomology majors. We have had a number of students who take an internship with some of the larger pest control companies, others with landscape operators and golf courses. For those who take the pest control option, all of them have received offers for employment upon graduation. One of the challenges is to convince these pest management companies that they need to develop a career ladder for persons with college degrees in order to retain them within the industry.

The course in Urban Entomology at Texas A&M University has a long and successful history based on the measurable outcomes of continuing education, employment longevity, and income potential. These parameters are tracked by our recruiting specialist. This person also works with potential employers in attempting to anticipate what characteristics they are looking for in future employees, particularly those with college degrees. What has been interesting, as reported by our recruiter, and from discussions conducted with potential employers, is that they like the fact that the students have basic science backgrounds, including the ability to identify insects. But they are looking at the students' abilities to learn new material, to present a positive image in public, to have speaking and writing skills, to know how to solve problems, to supervise other employees, to work independently, and to have some basic understanding of business, including ethics. In other words, the subject matter we provide in the Department of Entomology had to be re-evaluated. As I have considered these requisites for employment, changes had to be made in my syllabus, as well as in presentation methods.

In working with our Center for Teaching Excellence, I have learned that students learn in different ways including: visual (outlines, notes, and demonstrations); auditory (specific instructions, discussions, examples); and kinesthetic (touching, feeling, seeing). Most of us learn by using all three approaches, but we have preferences for one or the other. Studies of the ways that students learn and retain information have resulted in the "Learning Pyramid" which is summarized as the following:

– Lecturing (5%)
– Reading (10%)
– Audio/Visual (20%)
– Demonstrations (30%)

- Discussions (50%)
- Practice by Doing (75%)
- Teaching Others (90%)

This is a hierarchal system which builds on itself to attain the higher percentages of information retention.

In attempting to incorporate the principles of the “Learning Pyramid”, it was necessary to revise the teaching approaches used in Urban Entomology. The framework was a three-credit course, with two 50-minute lecture periods per week and a required 3-hour laboratory. The lectures were presented in PowerPoint, but an effort was made to include practical and personal experiences in the discussions. The lectures were also closely correlated with the laboratory sessions, where the basic biology was discussed in class, and the sight identification was covered in the laboratory. The laboratory also provided opportunities for the students to experience “urban entomology” rather than just hearing about it. There were laboratory exercises in bioassays, pesticide application equipment and calibration, as well as a “hands on” field trip to the termite control training center, an interactive session with a state regulator official involved with licensing and certification of pest management professionals, and a similar session with persons who work in the pest management industry. A research project was required, which involved a review of literature, a collection of information, a written report, and an oral presentation using PowerPoint, presented to the entire class. This course is considered, based on evaluations by the students, as being too rigorous for the three hours of credit received; however, students completing the course who wanted to work in urban pest management had a 100% placement rate.

One of the reasons for high employment rates for students with a background in urban entomology is based on the demographics of Texas. Our population is rated as 80% urban and/or suburban, and 20% rural. Another survey indicated that 87% of Texans recognized insects in and around their homes, places of business, schools, or recreation areas. What has become very apparent to the administration of Texas A&M University is that our clientele are largely urban based, and while we have a major commitment to an agricultural audience, the voting and taxation base of our state is now urban. This audience is demanding services from their land grant institutions, which hopefully will cause the shift in provided funding to more urban programs, some of which are centered in the Entomology Department. The Extension programs in Texas have taken on a definite urban emphasis, as indicated by the hiring of several positions at the district level for Master’s level entomologists. These positions were initially funded through the fire ant programs, but are gradually being expanded to be more inclusive. The majority of these specialists are urban entomology graduates.

It is apparent that the need for well-trained urban entomologists will increase, particularly as positions are made available, which is anticipated. In our case, with the increasing interest in forensics, and the need to solve insect problems in urban and structural environments, Urban Entomology is, in fact, the future of the entomological sciences.

SYMPOSIUM

BIODIVERSITY OF TERMITES FROM THE AMERICAS

19 May 2008

Organizers:
Allen L. Szalanski (University of Arkansas) and James W. Austin (Texas A&M University)

PHYLOGEOGRAPHY OF *RETICULITERMES* FROM THE WESTERN UNITED STATES

Allen L. Szalanski
University of Arkansas, Fayetteville, AR

Investigations have been conducted on genetic diversity of *Reticulitermes* from the western United States. Introductions of eastern Nearctic *Reticulitermes* to the west are identified. Both *R. flavipes* and *R. hageni* have been confirmed in Oregon, while *R. flavipes* can be found in several western states. The frequency and distribution of their presence and potential damage to urban structures remain unknown. High levels of genetic diversity have been identified in *R. tibialis* and *R. hesperus*. Phylogenetic analysis reveals support for cryptic species of *Reticulitermes* in several western states.

IDENTIFICATION AND BIOGEOGRAPHY OF TERMITE SPECIES FROM TEXAS

James W. Austin
Texas A&M University, College Station, TX

A comprehensive evaluation of termite species from Texas has never been performed, and the exact distribution of these species is currently unavailable. Identification of species based on published accounts, as well as from personal, private and university collections, suggests several species occurring in Texas that have never been documented. The geographical diversity of Texas' landscape can sustain several different specialist groups of termites; 4 families, 12 genera, and approximately 30 species of termites demonstrates Texas as possessing the greatest termite diversity among all continental states in the U.S.

Biogeographical and historical information about the diversity of termite species in Texas support this hypothesis. A concerted effort to genetically categorize all species in Texas through genetic bar-coding offers an opportunity to identify new introductions to the state. Clarification of species' identities through genetic tools allows improved insight into the distribution, gene flow, and patterns of geographical isolation in the diverse habitats of the state, which is particularly important to understanding termite groups such as the higher termites *Amitermes*, *Gnathamitermes*, and *Tenuirostritermes*.

PATTERNS OF ENDEMNICITY OF NEW WORLD TERMITES

Timothy G. Myles
Center for Urban and Community Studies, University of Toronto,
Toronto, Ontario, Canada

The geographic ranges of New World termite genera and presumed supra-generic clades are plotted and analyzed. Patterns of separation between North and South American endemic genera serve to indicate the endemic composition of the termite fauna of each continent prior to the formation of the Panamanian Isthmus. This analysis also helps to suggest which other taxa have interchanged. The southern Nearctic termite fauna is characterized by moderately rich endemic radiations among the drywood termites (Kalotermitidae) and the desert Amitermitinae, with minor endemic elements among the Nasutitermitinae and Apicotermitinae. The endemic character of the termite fauna of the Nearctic region is currently underappreciated due to an erroneous tendency to lump the southern endemic elements of our fauna within the "Neotropical Region" and also due to the fact that many endemic genera remain to be described and are currently lumped inside *Neotermes, Incisitermes, Amitermes, Gnathamitermes, Nasutitermes,* and *Anoplotermes*, all of which require splitting out of new endemic Nearctic genera. South America has a much richer and very distinctly different termite fauna with several unique elements among the Serritermitidae, Rhinotermitidae, Apicotermitinae, Termitinae, and is especially diverse among the mandibulate nasutes and fully nasute Nasutitermitinae.

INVASIVE TERMITES IN THE AMERICAS

Rudolf H. Scheffrahn
Fort Lauderdale Research and Education Center, University of Florida, Davie, FL

Defined as "alien species whose introduction causes economic harm", I will review the status of invasive termite species occurring in the New World. Invasives with New World origin include the major pests *Cryptotermes brevis*, *Heterotermes* spp., and *Nasutitermes corniger*, and two with minimally invasive habits, *Incisitermes minor* and *Coptotermes testaceus*. Invasives introduced into the Americas from the Old World include the major pests *Co. gestroi* and *Co. formosanus*, while *Cr. havilandi*, *Cr. dudleyi*, and *Co. sjostedti* have minor invasive tendencies.

PHYLOGENY AND GEOLOGICAL HISTORY OF TERMITES

Michael S. Engel
Department of Ecology & Evolutionary Biology, University of Kansas, Lawrence, KS

A study of phylogenetic relationships among major lineages of Isoptera is provided based on morphological and ethological data. For the first time an extensive sampling of fossil termites from the Tertiary and Cretaceous periods, including an abundance of “primitive” termites newly discovered and described during the last year, has been synthesized with neontological evidence. This comprehensive paleontological and neontological analysis recovers major patterns of diversification of termites during the Cretaceous and again in the middle Tertiary. Most Cretaceous taxa are found to represent stem groups to either the modern families or as intermediate between groups of families, including one genus as a stem group to all other Isoptera. Mastotermitidae falls relatively basal in the order, among a diversity of fossil taxa. Termopsidae and Hodotermitidae as widely defined were not recovered as monophyletic with components of these families emerging from a grade of living and fossil termites lineages leading to Kalotermitidae as closely related to the higher termites (Rhinotermitidae + Termitidae). There is relatively tight stratigraphic-rank correlation, with the earliest fossils falling more basal in the order. The analysis indicates that the higher termites, particularly the ubiquitous Termitidae radiated during the Tertiary.

SUBMITTED PAPERS

TERMITES

20 May 2008

A NEW APPROACH TO MARKING SUBTERRANEAN TERMITES TO STUDY FORAGING AND FEEDING POPULATION DISPERSAL

Paul Baker[1] and James Hagler[2]
[1]Department of Entomology, Tucson, AZ
[2]USDA-ARS, Arid Land Agricultural Research Center, Maricopa, AZ

Studies were conducted to investigate the feasibility of marking the southwestern desert subterranean termite, *Heterotermes aureus* (Snyder), with rabbit immunoglobulin G (IgG) protein for mark-release-recapture (MRR) and mark-capture studies. Laboratory studies were conducted to determine how long rabbit IgG is retained on or in *H. aureus* that were marked either externally with a topical spray, internally by feeding them a rabbit IgG marked food source, or both internally and externally (double marked). Marked termites were detected by an anti-rabbit IgG enzyme-linked immunosorbent assay (ELISA). Data indicated that the termites retained the mark well for up to 42 d, regardless of the marking procedure.

We applied the rabbit IgG marking procedure to a field mark-capture dispersal study. The study grid consisted of cardboard impregnated with rabbit IgG placed at a central location infested with *H. aureus*, with 50 other unmarked bait stations placed at predetermined distances surrounding the centrally marked station. Eleven of the 51 termite collection stations within one study site were infested with *H. aureus* 30 days after the rabbit IgG-marked cardboard roll was placed in the field. Termites (14.8%) were well marked which suggests that the protein mark displays both spatial and temporal durability in the field. The advantages and limitations of protein marking termites with rabbit IgG for MRR or mark-capture termite studies are discussed.

EFFICACY OF THE EXTERRA™ SYSTEM WITH LABYRINTH AC™ TERMITE BAIT IN OHIO FIELD TRIALS

Susan C. Jones and Nicola T. Gallagher
Department of Entomology, Ohio State University, Columbus, OH

The objective of this research study was to assess the effectiveness of the Exterra™ system in controlling structural infestations of the eastern subterranean termite, *Reticulitermes flavipes*. The study was initiated in spring 2006, with the installation of stations at six termite-infested structures in Columbus, OH (Franklin County). Termites quickly infested Exterra™ monitoring stations at all six sites, with the percentage of infested stations ranging from 9 to 69% after just one month. Termites subsequently consumed large amounts of Labyrinth AC™ termite bait (0.25% diflubenzuron in an alpha cellulose matrix). At five of the six structures, termites were eliminated within 3 months and no further evidence of termites was observed during a 1-year post-inspection period. Multiple colonies were present at one structure, so it took ~15 months until the structure was free of termites. These field trials indicated that the Exterra™ system effectively controlled subterranean termites.

MUNICIPAL TERMITE CONTROL PROGRAMS IN ONTARIO, CANADA

Timothy G. Myles
Building Services, 59 Carden St., Guelph, Ontario, Canada

Termites are not native to Ontario, historically having been excluded by the Great Lakes system which acts as a physical barrier to their northern movement. Over the past 80 years, the eastern subterranean termite, *Reticulitermes flavipes,* has been introduced by commerce (shipping and rail), subsequently spread by the gradual lateral expansion of colonies, and further spread by the inadvertent movement of infested material. Subterranean termites are now known in over 30 Ontario municipalities. In two widely separate areas, the Windsor area (Essex Co.) and the City of Toronto, termite infestations are so widespread as to be beyond area-wide management and therefore may as well be managed on a conventional property-specific basis. However, in numerous other southern Ontario municipalities, e.g., Mississauga, Oakville, Hamilton, Thornhill, Newmarket, Innisfil, Pickering, Oshawa, Guelph, Kitchener, Elora, Fergus, Kincardine, and possibly others, termites remain highly localized, and their populations may therefore be effectively managed on an area-wide basis. Generally, cities in which the termite-infested area occupies less than a 50-block area may be considered manageable on an area-wide basis. The City of Guelph is taken as an exemplary case study for which the history, success, and status of termite control efforts are reviewed.

CONTROLLING TERMITES USING SPOT TREATMENTS AND LOCALIZED PERIMETER BAND APPLICATIONS OF PREMISE® GRANULES

Philip McNally[1], Vince Parman[2], Gary Braness[3], John Paige[4], and Chip Anderson[5]
[1]Bayer Environmental Science, Clayton, NC
[2]Bayer Environmental Science, Apex, NC
[3]Bayer Environmental Science, Kansas City, MO
[4]Bayer Environmental Science, Vero Beach, FL
[5]Bayer Environmental Science, Fayetteville, GA

Premise® Granules (0.5% imidacloprid) were registered by the Environmental Protection Agency (EPA) in December 2005. This presentation summarizes the label-supportive studies and field evaluations conducted by university researchers and commercial pest management professionals (PMPs) from five states (North Carolina, Missouri, Florida, Alabama, and Arizona). Premise® Granules broadcast at 1.8 lbs of formulation/1000 square feet provided protection for up to at least 5 months in ongoing studies. Where Premise® Granules were incorporated in soil as a spot treatment at 5.0 oz of product per square foot or as a localized trench treatment at 3 oz of product per linear foot adjacent to 70 active termite shelter tubes containing workers of either *Reticulitermes* spp., *Coptotermes formosanus*, or *Heterotermes aureus*, cessation of activity was noted within 7 days in 96% of the shelter tubes and remained at 98% throughout the evaluation period of the study. These studies support using Premise® Granules in an alternative use pattern to kill termites as a spot treatment or low rate perimeter band.

DOSE, DISTANCE AND TRANSFER EFFECTS OF INDOXACARB AGAINST THE WESTERN SUBTERRANEAN TERMITE (ISOPTERA: RHINOTERMITIDAE)

Donald A. Reierson[1], Raj K. Saran[2], and Michael K. Rust[1]
[1]Department of Entomology, University of California, Riverside, CA
[2]McLaughlin Gormley King, Minneapolis, MN

Despite continued development and improvement of baits for termite control, liquid termiticides are the most common method to protect structures from the western subterranean termite, *Reticulitermes hesperus*. Fipronil (Termidor®), imidacloprid (Premise®), and a few others provide an effective residual barrier that protects structures from termite attack. As opposed to providing a repellent barrier through which termites will not penetrate, these chemicals are relatively slow acting and non-repellent, providing kill through prolonged or repeated exposure of foragers. Horizontal transmission of toxicant has also been reported as a significant component of control.

This study examined the termiticidal and behavioral effects of indoxacarb, a novel oxadiazine pro-insecticide reportedly requiring metabolic activation, against *R. hesperus*. Indoxacarb is designated as a “low risk” insecticide due to its mode of action, selectivity, and good environmental use profile. Our initial topical trials indicated a high level of delayed toxicity, low-level repellency, and horizontal transmission. Using more elaborate laboratory trials, we determined the acute and chronic toxicity of indoxacarb against termites (ng/termite at 1 wk, LD_{50} = 1.24; LD_{95} = 5.07), and we also assessed its important delayed toxicity and behavioral effects and its potential for horizontal transfer at various doses and ratios of donor (exposed) and recipient (unexposed) termites. Lethal dose decreased >3- to 5-fold if observations were made at 2 to 3 wks rather that at 1 wk. This prolonged delayed toxicity was unique for indoxacarb. By comparison, the topical LD_{50} of fipronil was 0.22 ng/termite at wk 1 and was not different for wk 2 or 3. Indoxacarb-treated soil achieved maximum knock down (KD) at about 10 d, again indicating its slow activity. Relevant exposure (i.e., 1 hr) to >50 ppm provided 100% kill by day 8. Doses as high as 200 ppm did not reduce time to kill. The threshold for tunneling was ca. 10 ppm, although only minimal tunneling occurred and 79% died by 7 d. At >25 ppm, no tunneling was observed and 100% mortality occurred by 7 d. Even 200 ppm indoxacarb in soil was not repellent. Indoxacarb toxification also inhibited termite movement. Locomotion, as measured by the termite's ability to traverse a trail-following pheromone segment, was inversely related to time post-exposure. Locomotor inhibition probably also deters tunneling.

At least 25 ppm indoxacarb was needed for measurable horizontal transmission to occur. At 200 ppm, <20% donors caused >40% mortality among recipients at 15 d. Although measurable, there was no dramatic horizontal transmission effect. Based on the toxicity of indoxacarb to individual termites, we calculate from our transfer studies that horizontal transfer occurs, but its direct effect in terms of control may be minimal. Sensitivity to low doses and greatly delayed toxicity are, however, important major characteristics of indoxacarb. Linear foraging trials indicate that most mortality occurs within up to ca. 20 ft (6.1 m), regardless of dose. This is consistent with the delayed toxicity effects seen in our other tests. Based on our studies, indoxacarb is indeed a promising "low risk" compound for controlling the western subterranean termite.

SASHIMI: A COMPONENT OF THE ISOPTERAN PALATE?

Joe E. Eger, Jr.[1], Matt T. Messenger[2], S. Buckley[3], L. Remmen[4], Allen L. Szalanski[5], and Jackie A. McKern[5]
[1]Dow AgroSciences, Tampa, FL
[2]Dow AgroSciences, Indianapolis, IN
[3]Dow AgroSciences, Mougin, France
[4]Sparta, NJ
[5]Department of Entomology, University of Arkansas, Fayetteville, AR

In June 2005, the first and second authors spent two weeks in the Kaw Mountains of French Guiana on an insect collecting trip. During this time, we observed subterranean termites (*Nasutitermes* sp.) (Isoptera: Termitidae) feeding on fish heads that were secured to the ground to attract other insects. Specimens of these termites collected for identification were lost to the actions of Hurricane Katrina. On a subsequent trip in April 2007, additional fish heads were placed on the ground in the same areas. We again observed *Nasutitermes* sp. feeding on the fish and collected specimens for identification.

These observations of Neotropical termites feeding on fish suggested that there might be some component of fish carrion that would improve the attractiveness of termite monitors to *Reticulitermes* spp. (Isoptera: Rhinotermitidae). To evaluate this potential attractant, we initiated field trials in Florida, Delaware, and France in which small bait fish were added to Sentricon® stations equipped with wood monitors. In some of these trials the addition of fish to the stations resulted in a significantly increased percentage of stations with termites. However, results were not consistent and the magnitude of response probably precludes the utility of 'sashimi' to enhance rhinotermitid activity.

DNA ANALYSIS OF THREE SPECIES OF SUBTERRANEAN TERMITES ON THE DELMARVA PENINSULA

Susan King[1], Carl Schmidt[2], and Bruce Kingham[2]
[1]Department of Entomology and Wildlife Ecology, University of Delaware, Newark, DE
[2]Department of Animal and Food Science, University of Delaware, Newark, DE

Abstract

DNA analysis was conducted on three species of subterranean termites in Delaware, *Reticulitermes flavipes*, *Reticulitermes virginicus*, and *Reticulitermes malletei*. A region of the 16S ribosomal RNA gene along with a segment of cytochrome oxidase subunit II gene were sequenced. Results showed that there are at least four strains of *R. flavipes* in Delaware (Rf1.3, Rasd5-1, BH13 and VoucherG72). These different strains are distributed throughout the peninsula with no obvious localization for any specific strain. Ribosomal RNA sequences showed that, in addition to previously known sites in Lewes, DE, *R. malletei* is present in at least five other sites on the Delmarva peninsula.

Introduction

Three species of subterranean termites, *Reticulitermes flavipes*, *Reticulitermes virginicus*, and *Reticulitermes malletei*, have been collected from monitoring stations established on a six hectare pine-scrub sand beach at Cape Henlopen on the Delaware Bay in Lewes, DE (King et al. 2007). Whereas *R. flavipes* alates can be distinguished from alates of the other two species of *Reticulitermes* on the basis of the distance of the ocellus from the compound eye and *R. flavipes* soldiers can be distinguished from those of the other two species on the basis of the width of the pronotum, *R. virginicus* cannot be separated from *R. malletei* based on its external morphology (Austin et al. 2007). DNA analysis is required to identify alates and soldiers of the two species.

In this study, termites were collected on the Delmarva peninsula, which includes portions of eastern Maryland, northeastern Virginia, and the whole of Delaware. DNA sequencing was conducted in an attempt to answer the following questions:
1. How closely related are colonies of *R. flavipes* on the Delmarva peninsula?
2. What is the geographic distribution of *R. malletei* on the Delmarva peninsula?

Materials and Methods

From more than 800 termite samples taken from 1996 through 2007, 222 were chosen for DNA sequencing. Each sample had been maintained in 85% ethanol and each contained at least five soldiers. Most samples had been collected during 2006 and 2007; however the set of 222 vials held at least one sample from each year. Termites were collected from fallen logs, and samples from Lewes numbered 150; those from nearby southern beaches numbered 35, and those from northern hardwood forests numbered 37.

<u>DNA Preparation</u>**:**
From each sample vial, two to three termite soldiers (≤50 ug of termites; EtOH-fixed) were removed to a labeled dish or wax paper and allowed to dry at room temperature (~15–30 minutes). The dried termites were transferred to labeled 1.5 ml microcentrifuge tubes and spun briefly and then placed at -80ºC for ≥15 minutes. The frozen termites were ground with a microcentrifuge pestle and then digested and DNA extracted using Qiagen DNeasy Blood & Tissue kit (Qiagen Inc., Valencia, CA).

They were spun at 20K x g to collect undigested material at the bottom before adding digest to the column. The genomic DNA concentration was determined using a Nanodrop spectrophotometer.

PCR Reaction:
Genomic DNA (10 – 100 ng) was used in a 40 ul PCR reaction with 40 picomoles of gene-specific primers. The conditions for PCR were: 94ºC for 1 minute; 35 cycles of 94ºC for 30 s, 46ºC for 30 s, 72ºC for 45 s; one cycle at 72ºC for 7 minutes. Following reactions, the product was purified using QIAquick PCR Purification kit (Qiagen Inc.), as per manufacturer's instructions, and yield was determined with a Nanodrop spectrophotometer. For sequencing, between 10 – 20 ng PCR product was used in a 10 ul sequencing reaction with 3.6 pmols gene-specific primer.

Gene-specific primers (16S ribosomal gene, and cytochrome oxidase II [COII] gene) were:
16S-forward: 5' - TTA CGC TGT TAT CCC TAA - 3'
16S-reverse: 5' - CGC CTG TTT ATC AAA AAC AT - 3'
COII-forward: 5' - TCT TCT TCC ACG AYC AYA CAY TAA TAA - 3'
COII-reverse: 5' - TTT ATG GGT AGT ACY ATT CGY TT - 3'

DNA Sequencing:
DNA sequencing was conducted by the University of Delaware sequencing core facility on an ABI3130 capillary device.

DNA Sequence Interpretation:
Students in the University of Delaware Bioinformatics class (ANSC644, Fall 2007) edited the sequence results using FinchTv. Concatemers of the COII and S16 sequences for each sample were aligned using ClustalW (Higgins et al. 1994).

Results

How closely related are colonies of *R. flavipes* on the Delmarva peninsula?
Sequencing showed that there are at least four strains of *R. flavipes* on the Delmarva peninsula (Figure 1):

- Rf1.3 - Broadkill Beach, Slaughter Beach, Fenwick Island, and Lewes (all on the southern coast of Delaware)
- Rasd5-1 – Lewes, DE
- BH13 – Newark in northern Delaware
- VoucherG72: Elk Neck State Forest in northwestern Maryland and Lewes, DE

These different strains are distributed throughout the peninsula with no obvious localization for any specific strain.

What is the geographic distribution of *R. malletei* on the Delmarva peninsula?
Sequencing showed that, in addition to previously known sites in Lewes, DE, *R. malletei* was present in at least five other sites on the Delmarva peninsula (Figure 1). In Delaware, it was collected from two northern hardwood sites (Rittenhouse Park and the Stein-Haskel Research facility in Newark) and two southern beaches (Slaughter Beach and Prime Hook Beach). In Maryland, it was collected from Elk Neck State Park in Elkton, another northern hardwood site.

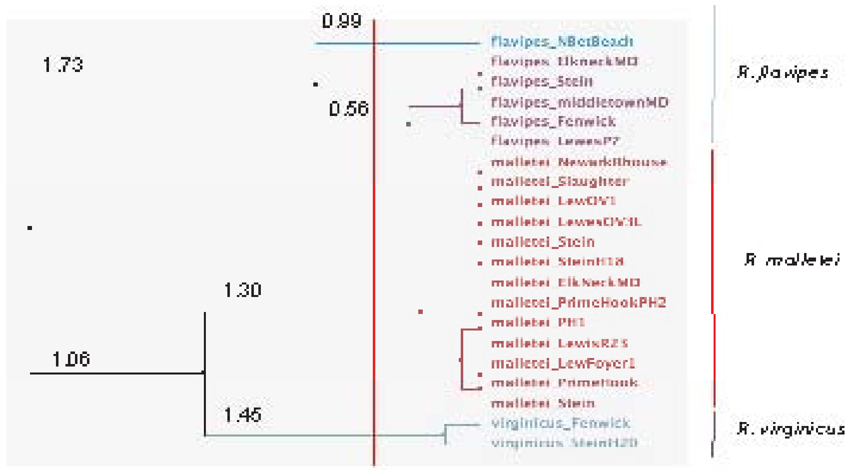


Figure 1. Phylogenetic tree of three subterranean termite species.

Conclusions

Until this study was conducted, it was assumed that *R. malletei* was not present on the Delmarva peninsula outside of Lewes, DE (King, unpublished data). Results of DNA sequencing show that this species is common from the southern part of the peninsula to the north. Future studies in Lewes, DE, will examine reproductive isolation between *R. malletei* and *R. virginicus* and resource partitioning between *R. malletei* and *R. flavipes*.

Acknowledgments

This study was made possible by a University of Delaware College of Agriculture and Natural Resources Teaching Mini-Grant, and support from Dow AgroSciences and DuPont Professional Products. The authors would like to thank the University of Delaware 2008 Bioinformatics class for their assistance.

References

Austin, J. W., A.-G. Bagneres, A. L. Szalanski, R. H. Scheffrahn, B. P. Heintschel, M. T. Messenger, J.-L. Clément, and R. E. Gold. 2007. *Reticulitermes malletei* (Isoptera: Rhinotermitidae): a valid Nearctic subterranean termite from eastern North America. Zootaxa 1554: 1-26.

Higgins, D., J. Thompson, T. Gibson, J. D. Thompson, D. G. Higgins, and T. J. Gibson. 1994. CLUSTAL W: improving the sensitivity of progressive multiple sequence alignment through sequence weighting, position-specific gap penalties and weight matrix choice. Nucleic Acids Research 22: 4673-4680.

King, S. W., J. W. Austin, and A. L. Szalanski. 2007. Use of soldier pronotal width and mitochondrial DNA sequencing to distinguish the subterranean termites, *Reticulitermes flavipes* (Kollar) and *R. virginicus* (Banks) (Isoptera: Rhinotermitidae), on the Delmarva peninsula Delaware, Maryland, and Virginia, U.S.A. Entomological News 118 (1): 41-48.

COULD WOOD-FEEDING TERMITES PROVIDE BETTER BIOFUELS?

Jian-Zhong Sun
Coastal Research and Extension Center, Mississippi State University, Poplarville, MS

Abstract

Termites, especially wood-feeding species, often are structural pests in urban areas. They are among the most important and effective lignocellulose-digesting invertebrates on Earth; they exhibit an incredible capability for lignocellulosic degradation via their specialized intestinal symbiotic association with prokaryotic and eukaryotic microorganisms. An understanding of the way termite guts process food could advance scientific endeavors to produce renewable energy from cellulosic biomass and help solve the world's imminent energy crisis. In order to economically produce lignocellulosic biofuels, new enzymes to convert plant material efficiently must be discovered. An array of complex enzymes in termite guts can be identified either from the termite itself endogenously or from the diverse symbiotic microorganisms inhabiting the hindgut paunch. These microbes could be used as a rich source of genes and enzymes for improving the bioconversion of lignocellulose to valuable biofuels. Clearly, it would be beneficial for the biofuels industries if we fully understood the mechanisms of wood degradation by termites. Another impressive characteristic of wood-feeding termites is their ability to emit large quantities of energy gases (H_2 and CH_4), which suggests a potential source of biohydrogen via termites and a unique mechanism for producing valuable biohydrogen. This mini-review addresses the potential values, various challenges, and opportunities for using wood-feeding termites in the production of viable biofuels.

Introduction

Termites are widely distributed throughout the world, and they play a critical role in recycling wood and other lignocellulosic biomass. They are so successful at digesting timber that they cause more than $1 billion in damage each year to homes and buildings throughout the U.S. However, these wood-feeding termites could be beneficial because their unique mechanisms and roles in wood degradation could serve as an ideal bioconversion model for refining lignocellulose-based biofuels.

Global warming and escalating petroleum costs in recent years are creating an urgent need to find ecologically sustainable fuels, such as bioethanol and biohydrogen. Plant material is the most abundant lignocellulosic biomass on Earth, consisting mainly of cellulose (~44%), hemicellulose (~30%), and lignin (~26%). Lignocellulosic biomass, including agricultural and forestry waste residues, has the potential to become a major source of fermentable sugars for biofuels in the future. It is estimated that in the U.S. alone, more than one billion tons per year of biomass could be sustainably harvested in the form of crop and forestry residues; this is enough to satisfy as much as 30% of the total U.S. gasoline consumption (Merino and Cherry 2007).

One of the crucial steps in bioethanol production is the hydrolysis of cellulose and hemicellulose to monomer sugars, e.g., glucose, xylose, or mannose. The most promising method for the hydrolysis of cellulose to glucose is by use of cellulases— an enzyme complex capable of breaking down cellulose to β-glucose. However, the logistical challenge we face in lignocellulosic bioconversion is how to scale up biofuel production in an efficient, economic, and sustainable way.

Unique Enzyme Systems Involved In Wood Degradation by Termites

Termites are among the most important and effective lignocellulose-digesting insects on Earth (Figure 1), and their guts could potentially serve as a bioreactor model and a novel source of catalysts in bioconversion of lignocellulose to fermentable sugars. Early reports suggest that termites could efficiently decompose lignocellulose within 24 hrs by degrading 74-99% of the cellulose, 65-87% of the hemicellulose, as well as 5-83% of the lignin of their ingested plant material (Prins and Kreulen 1991, Itakura et al. 1995, Konig et al. 2006, Sun et al. unpublished data). This suggests that termites might potentially hold a vital key for efficiently bioconverting lignocellulose to biofuels.

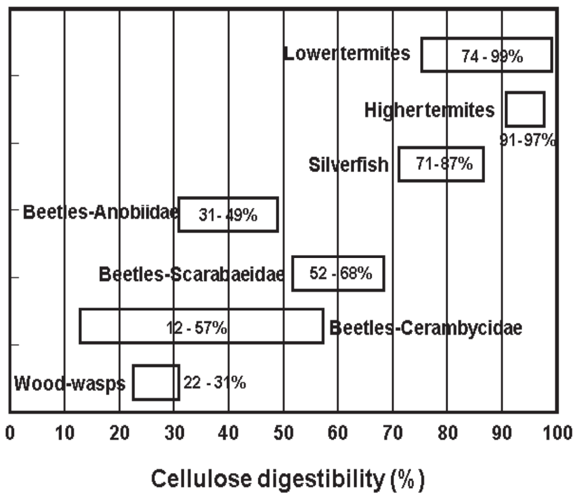


Figure 1. Cellulose digestion in some insects (adapted from Prins and Kreulen 1991).

At least three distinctive types of glycosyl hydrolases are involved in the biological conversion of cellulose to glucose--endoglucanases (EG, EC 3.2.1.4), cellobiohydrolases (CBH, EC 3.2.1.91), and β-glucosidases (BGL, EC 3.2.1.21) (Li et al. 2006)--all of which are present in the gut system of wood-feeding termites. The lower termites, all of which possess symbiotic protozoa in the hindgut, demonstrate a dual, independent cellulose-degrading system because they can synthesize their own cellulases (Watanabe et al. 1998, Nakashima et al. 2002a) in addition to using protozoa-derived glycosyl hydrolases for effective and synergistic cellulose degradation. In the higher termites, all of which lack protozoa, lignocellulolytic enzymes are primarily generated from a symbiotic bacterial community in their hindguts (Tokuda and Watanabe 2007).

Both lower and higher wood-feeding termites possess a variety of efficient lignocellulolytic enzymes that are unique as they are found nowhere else in nature due to the specific, obligate symbiotic relationship between the termite and its microbiota. It is believed that the guts of these wood-feeding termites could be used as a rich source of enzymes for improving the conversion of wood or waste biomass to valuable biofuels (Warneche et al. 2007).

Lignocellulolytic Microbes in the Termite Hindgut

Most of these symbiotic microorganisms inhabiting the termite hindgut, including the protists in lower termites and the bacteria responsible for lignocellulose degradation in higher termites, are culture-independent and difficult to isolate for growth and identification by traditional culturing methods. In the hindgut of lower termites, wood particles are endocytosed by symbiotic protists and decomposed within their food vacuoles (Yamaoka 1979). The challenges associated with maintaining an organism in pure culture restricted the identification and characterization of protozoa-derived cellulases until culture-independent PCR technology was employed.

Using PCR technology, scientists identified several diverse genes encoding protist cellulases of the glycosyl hydrolase families 5, 7, and 45 (GHF 5, 7, and 45) from the hindguts of two lower termites, *Reticulitermes speratus* and *Coptotermes formosanus* (Ohtoko et al. 2000, Nakashima et al. 2002b, Inoue et al. 2005). These studies demonstrate that the symbiotic protists in lower termites may be a rich source of novel cellulase genes. These diverse cellulase genes could potentially be cloned into *Escherichia coli* or other vector bacteria, allowing cellulases to be mass produced to generate biofuels (Nakashima et al. 2002b). Considering the substantial activity of xylanase that was found in the hindgut of these lower termites, diverse glycosyl hydrolases also are expected to exist in symbiotic protists (Inoue et al. 1997, 2005).

Symbiotic bacteria in the hindguts of wood-feeding higher termite species decompose wood substrates efficiently despite the absence of gut protists. However, it is extremely difficult to grow these bacteria in pure culture using traditional microbiology techniques. The demand for the identification of novel biomass-degrading enzymes from these symbiotic bacteria, the need for heterologous protein production at higher efficiencies, and the exigency of reducing the costs of commercial cellulases has generated an interest in obtaining genomic sequences of these symbiotic bacteria. An emerging technology, metagenomics, involves the study of all genetic material obtained from particular environments; it is a viable tool for addressing the challenges associated with studying bacterial communities in termite guts. Metagenomics allows the investigation of microorganisms that cannot be cultured in the laboratory (Streit and Schmitz 2004, Brune 2007).

After two years of effort by a group of scientists in the U.S., a metagenomics analysis of the gut bacteria from a higher termite collected from Costa Rica, *Nasutitermes ephratae*, has successfully revealed a diverse range of bacterial cellulase and xylan hydrolase genes. The results also include about 1,000 bacterial genes encoding lignocellulose hydrolases enzymes, some of them expressed *in situ* in living termites (Warneche et al. 2007). For the first time, scientists have shown that bacteria in termite guts encode a diversity of genes and enzymes that may play a role in wood degradation.

Numerous microbes isolated from termite guts that demonstrate lignocellulolytic activities have been recently identified as potential sources of biochemical catalysts for degrading wood or other lignocellulose into biofuels. These symbiotic microbes and their lignocellulolytic enzymes show promise for industrial use. From the evidence observed in laboratory bioassays, many of the enzymes isolated from termites could have a significant synergistic effect on wood degradation when mixed with other commercial enzyme preparations (e.g., >47% more reducing sugar at 1:1 mixture than with pure commercial enzyme [Azuma and Koshijima 1984]). Therefore, the cellulases or other related hydrolases isolated from termite guts may act as unique catalysts and be an economically viable solution for the bioconversion of lignocelluloses.

Prospects

In conclusion, the potential and practical value of wood-feeding termites to generate biofuels from lingocellulosic materials can be summarized as follows:

1. The passage of wood particles through the digestive tract of a wood-feeding termite takes <24 h, which is a more efficient bioconversion than lignocellulose degradation by wood-rotting fungi. Therefore, further studies of this extraordinary gut ecosystem may lead to a novel bioreactor design for producing economically viable lignocellulose-based biofuels.

2. Most wood-feeding termites can only digest a minor amount (<30%) of the lignin present in wood substrates (Itakura et al. 1995) probably due to the anaerobic environment in their guts. The lignin polymer is then selectively discharged in the feces. In most cases the lignin skeleton is not destroyed in the termite feces, but some modification may occur in the termite body. This unique process indicates that a particular mechanism exists in termite guts to extract cellulose/hemicellulose from

the lignocellulosic matrix using their complex enzymes. Clearly, understanding this mechanism in the termite digestive tract could potentially aid in the development of an efficient, cost-effective biomass pretreatment technology, which is a required and critical process for biofuels production.

3. The symbiosis between termites and their gut microorganisms can be described as a synergistic interaction of endogenous enzymes from termites and the enzymes from their microbes. This dual enzymatic complex system provides a higher rate of hydrolytic degradation of cellulose and hemicellulose. Therefore, wood-feeding termites and their gut microbiota could serve as an extraordinary gene pool for enzymes that breakdown cellulose and hemicellulose--two of the main polysaccharides found in wood and agricultural plant residues.

4. Significant amounts of gases that can be used as energy sources, such as H_2 and CH_4, are produced as byproducts of wood digestion by termites. Average H_2 emission rates during 72 h incubation were measured as 1315±140, 2532±488, and 565±80 nmol h^{-1} g of body weight^{-1} for *Reticulitermes flavipes*, *Reticulitermes virginicus,* and *C. formosanus*, respectively (Cao et al. 2008). This suggests a potential source of biohydrogen via termites and a unique mechanism for producing valuable biohydrogen. In the future, termite guts can potentially be used as the world's smallest bioreactors to generate a large amount of biological H_2 in an effective, economic, and sustainable way from the digestion of lignocellulose.

5. Sequencing or cloning of termite symbiont genes using metagenomics, PCR, and other emerging biotechnologies has already shown promise in providing novel, active, and industrially viable microorganisms and enzymes for use in biofuels production. With continued efforts, the genes isolated from lignocellulolytic microbes in termite guts could potentially advance the bioconversion of lignocellulosic materials to valuable biofuels.

References

Azuma, J.-I., and T. Koshijima. 1984. Enzymatic saccharification of wood plants, II. Synergistic effects on enzymatic saccharification. Wood Res. (No. 70): 17-24.

Brune, A. 2007. Woodworker's digest. Science 450: 487-488.

Cao, Y. -Q, J.-Z. Sun, J. M. Rodriguez, and K. C. Lee, 2008. Hydrogen emission by three subterranean termite species (Isoptera: Rhinotermitidae): profiles and perspectives for continuous H_2 production. J. Insect Physiol. *In press*.

Inoue, T., K. Murashima, J.-I. Azuma, A. Sugimoto, and M. Slaytor. 1997. Cellulose and xylan utilization in the lower termite *Reticulitermes speratus*. J. Insect Physiol. 43: 235-242.

Inoue, T., S. Moriya, M. Ohkuma, and T. Kudo. 2005. Molecular cloning and characterization of a cellulose gene from a symbiotic protist of the lower termite, *Coptotermes formosanus*. Gene 349: 67-75.

Itakura, S., K. Ueshima, H. Tanaka, and A. Enoki. 1995. Degradation of wood components by subterranean termite, *Coptotermes formosanus* Shiraki. Mokuzai Gakkaishi 41: 580-586.

Konig, H., J. Frohlich, and H. Hertel. 2006. Diversity and lignocellulolytic activities of cultured microorganisms. pp. 271-301. *In* H. Konig and A. Varma [Eds.], Intestinal Microorganisms of termites and other invertebrates. Springer, Germany.

Li, L. J. Frohlich, and H. Konig. 2006. Cellulose digestion in the termite gut, pp.221-241. *In* H. Konig and A. Varma [Eds.], Intestinal Microorganisms of termites and other invertebrates. Springer, Germany.

Merino, S., and J. Cherry. 2007. Progress and challenges in enzyme development for biomas utilization. Adv. Biochem. Engin/Biotechnol. 108:95-120.

Nakashima, K. H. Watanabe, H. Saitoh, G. Tokuda, and J.-I. Azuma. 2002a. Dual cellulose-digesting system of the wood-feeding termite, *Coptotermes formosanus* Shiraki. Insect Biochem. Mol. Bio. 32: 777-784.

Nakashima, K. H. Watanabe, and J.-I. Azuma. 2002b. Cellulase genes from the parabasalian symbiont *Pseudotrichonympha grassii* in the hindgut of the wood-feeding termite *Coptotermes formosanus*. Cell. Mol. Life Sci. 59: 1554-1560.
Ohtoko, K., M. Ohkuma, S. Moriya, T. Inoue, R. Usami, and T. Kudo. 2000. Diverse genes of cellulase homologues of glycosyl hydrolases family 45 from the symbiotic protists in the hindgut of the termite *Reticulitermes speratus*. Extremophiles 4: 343-349.
Prins, R. A., and D. A. Kreulen. 1991. Comparative aspects of plant cell wall digestion in insects. Anim. Feed Sci. Technol. 32: 101-118.
Streit, W. R., and R. A. Schmitz. 2004. Metagenomics-the key to the uncultured microbes. Curr. Opin. Microbiol. 7: 492-498.
Tokuda, G., and H. Watanabe. 2007. Hidden cellulases in termites: revision of an old hypothesis. Biol. Lett. 3: 336-339.
Warneche, F., et al. (39 co-authors). 2007. Metagenomic and functional analysis of hindgut microbiota of a wood-feeding higher termite. Science 450: 560-565.
Watanabe, H., H. Noda, G. Tokoda, and N. Lo. 1998. A cellulase gene of termite origin. Nature 394: 330-331.
Yamaoka, I. 1979. Selective ingestion of food by the termite protozoa, *Trichonympha agilis*. Zool. Mag. (Tokyo) 88: 174-179.

EFFICACY OF IMIDACLOPRID GRANULES IN SOIL TREATMENTS AGAINST *RETICULITERMES FLAVIPES* (ISOPTERA: RHINOTERMITIDAE)[1]

Chris Keefer and Roger E. Gold
Texas A&M University, College Station, TX

Industry needs for safer transportation of termiticides to work sites, ease of application, and worker exposure safety have prompted the development of granular termiticides that specifically ameliorate these concerns. This presentation reports the results of field studies to evaluate this new termiticide technology.

Efficacy data were obtained for Premise® (0.5% imidacloprid) granule treatments around structures and in open field settings in Texas. All structures were built on monolithic slabs and received a spot treatment with Premise® granules at points of infestation 0.61 m either side of *Reticulitermes flavipes* shelter tubes. Applications of Premise® granules were made according to manufacturer's recommendations. Structures were inspected at 1 and 2 weeks and then monthly for 1 year post-treatment. Suppression of *R. flavipes* was sustained for 8 weeks in all five treatment replications following application of granules; in three of the five replicates, the treatment subsequently failed after 8 weeks as termite activity was observed in the structures.

An open field with active *R. flavipes* was utilized in this study. Grids measuring 8.53 m x 7.32 m were marked off, in-ground commercial termite monitors were installed, and grids were treated with Premise® granules. Un-treated pine boards were then placed within grids to determine if granules would suppress foraging and feeding on surface boards. Premise® granules suppressed surface feeding of *R. flavipes* for 9 months post-treatment, although termites were active throughout the study in the in-ground termite monitors within treated grids.

Results from these 1-yr studies demonstrated that Premise® granules suppressed *R. flavipes* for brief time periods around structures and in open field settings.

[1]*Presentation inadvertently was not listed in the NCUE 2008 Program.*

SUBMITTED PAPERS

ANTS & BEES

20 May 2008

EFFICACY OF SELECTED BAIT AND RESIDUAL TOXICANTS FOR CONTROL OF BIGHEADED ANTS, *PHEIDOLE MEGACEPHALA* (HYMENOPTERA: FORMICIDAE), IN LARGE FIELD PLOTS

John Warner, Rou-Ling Yang, and Rudolf H. Scheffrahn
Fort Lauderdale Research and Education Center, University of Florida, Davie, FL

Residual and bait product efficacies were compared against foraging ant populations in a field test for efficacy against bigheaded ants (BHA), *Pheidole megacephala*. At 7 days after exposure (DAE), the residual product Transport® (23% acetamiprid + 27% bifenthrin), Advion® fire ant bait (0.045% indoxacarb), and Siesta™ fire ant bait (0.063% metaflumizone) had significantly fewer ants than Arena™ 50 WP (50% clothianidin) and MaxForce® fire ant bait (0.0005% fipronil) which did not differ significantly from each other. All products had fewer ants than the controls. At 14 DAE, Transport® had fewer ants than the controls and other products, while Arena™ was not different than Advion® or Siesta™. At 28 DAE, MaxForce® had fewer ants than the controls and other treatments with the exception of Advion®, which did not have fewer ants than the controls. Residual treatments will likely need greater water volume to penetrate ground covers and soil to reach subterranean ants, and combined with a longer acting bait such as MaxForce®, should suppress BHA populations for at least 3 weeks.

LABORATORY AND FIELD EVALUATIONS OF FOUR BAIT FORMULATIONS FOR CONTROL OF *TAPINOMA SESSILE*

Preston H. Brown and Dini M. Miller
Department of Entomology, Virginia Tech, Blacksburg, VA

Laboratory and field evaluations compared the efficacy of four bait formulations (Advion® Ant Gel (0.05% indoxacarb), Advion® Ant Bait Arena (0.1% indoxacarb), Advance® Ant Gel Bait (5.4% sodium tetraborate decahydrate [borax]), and Maxforce® Ant Killer Bait Gel (0.001% fipronil) for control of the odorous house ant (OHA), *Tapinoma sessile* (Say) (Hymenoptera: Formicidae). No-choice arena tests were conducted to quantify mortality in laboratory OHA populations. After 11 d, mortality was the greatest for ants exposed to Advion® Ant Bait Arena, Advion® Ant Gel, and Advance® Ant Gel Bait (84% to 99%). OHA mortality resulting from Maxforce® Ant Killer Bait Gel (70%) was significantly less than that of the Advion® Ant Bait Arena but not significantly different from the control mortality (36%).

Field experiments were also conducted over 16 d at two residential locations, one in Christiansburg, VA, and the other in Roanoke, VA. Pre- and post-treatment baiting was conducted using cotton balls soaked with sugar water and placed in Petri dishes. These were placed near OHA foraging trails and left for 1 hour. The bait formulations (2.0 grams) then were applied to Petri dishes and placed next to the foraging trails for 24 hours. The bait formulations were replaced daily. Foraging ant pressure was determined by the number of ants feeding on the bait after 1 hour. Bait efficacy was determined by the reduction in foraging ant pressure from day 0 (pre-treatment) to day 16 (post-treatment).

The Advion® Ant Bait Arena produced the most rapid reduction of *T. sessile* populations (97% reduction by day 2) and maintained the greatest control throughout the test period (94% decrease at 16 d). At day 5, Advion® Ant Gel, Maxforce® Ant Killer Bait Gel, and Advance® Ant Gel Bait reduced foraging populations by 97.0%, 94.9%, and 73.0%, respectively. However, OHA populations exposed to these three bait formulations rebounded by day 16. The final percent reduction recorded for these bait formulations was 62.7% (Advion® Ant Gel), 65.7% (Maxforce® Ant Killer Bait Gel), and 50.1% (Advance® Ant Gel Bait). Control populations had a 22% increase over the 16-d test period.

ADVION® BAITS AND OPTIGARD™ ANT BAIT GEL REDUCE ODOROUS HOUSE ANT INFESTATIONS AROUND HOMES

Karen M. Vail, Jennifer Chandler, Joey Morton, and Pat Barnwell
University of Tennessee, Knoxville, TN

The odorous house ant (OHA), *Tapinoma sessile*, is the primary pest ant invading structures in the mid-south and elsewhere in the U.S. Two studies were conducted in Knox County, TN and surrounding areas during the spring/summer of 2007 to compare efficacy of commercialized pest control products against OHA found on or near structures.

Study A. This study evaluated two Dupont Advion® bait products against OHA found on or near structures. Treatments included (1) Advion® Ant Bait Arena (0.1% indoxacarb by wt.) applied indoors where ant activity was reported; (2) Advion® Mole Cricket Bait (0.22% indoxacarb by wt.) applied outdoors at 2.3 lb/1000 sq. ft. in a 5-feet band around the base of the structure; and (3) a combination of the ant bait arenas indoors and the mole cricket bait outdoors. Six structures were used per treatment and five were used for the untreated controls in this 12-week study.

For the combination of indoor bait arena and outdoor mole cricket bait application, the reduction in OHA worker numbers outdoors was significantly greater than the control for all days and remained above 85% throughout the first 6 weeks after baiting. The reduction in outdoor OHA numbers for the mole cricket bait treatment was never significantly different from the combination treatment although it remained above 85% for the first 2 weeks only. Although a reduction in outdoor OHA populations was observed in the houses that were baited indoors only, these reductions were never significantly different from the controls.

More ant activity was seen indoors when Advion® Ant Bait Arenas were used indoors by themselves compared to a combination of the mole cricket bait outdoors with the arenas indoors or the mole cricket bait by itself. It is important to place baits where and when ants are active and to move the stations if activity loci change. A comparison of Advion® Arenas or other outdoor ant baits used either in combination with the mole cricket bait or by themselves would be interesting. In the past we have been more successful in reducing indoor ant sightings by solely baiting outdoors.

Study B. The efficacy of Syngenta's Optigard™ Ant Gel Bait (0.01% thiamethoxam) and Whitmire Micro-Gen's Prescription Treatment® 388B Advance® Ant Gel Bait (5.4% sodium tetraborate decahydrate [borax]) was compared against OHA in and around homes and other structures. Baits were applied as crack and crevice treatments where trails with the highest levels of ant activity were observed. An average of 75 g of Optigard™ Ant Gel Bait and 101 g of Prescription Treatment® 388B Advance® Ant Gel Bait was applied to four structures each. Bait was applied so that all sides of each structure were treated. Structures were also treated indoors if ants were active inside. Four control structures received no treatment.

Due to high OHA populations, all houses were re-treated on August 9 and 10 (week 4) with the same bait as the previous treatment, but the bait was placed in Ant and Roach Buffet Stations (Innovative Pest Control Products, Boca Raton, FL), which were anchored to the ground with large nails. An average of 72 g of Optigard™ Ant Gel Bait and 127 g of Prescription Treatment® 388B Advance® Ant Gel Bait was used per structure. The amount of bait placed in cracks and crevices or in stations did not differ significantly between treatments.

The Optigard™ Ant Gel Bait effectively lowered outdoor ant populations on and near structures by greater than 80% within one day after crack and crevice placement. However, by 4 weeks after baiting, OHA populations had returned to pretreatment levels and re-baiting was initiated. One week after re-baiting, reductions in ant populations at houses treated with Optigard™ Ant Gel Bait had reached 79% and stayed above this for the duration of the study, reaching 98% reduction at 11 weeks.

For the Optigard™ Ant Gel Bait, control was maintained for a longer period when the baits were applied in a station rather than in cracks and crevices. We likewise have observed similar results with another manufacturer's experimental gel bait that was applied in Ant and Roach Buffet Stations and as a crack-and-crevice treatment (Vail, unpublished data). The longer control achieved with the Optigard™ bait in the station may have been affected by the time of year when OHA populations naturally decline. We would need to place a gel bait in cracks and crevices at the same time as in stations in order to directly compare the two delivery methods.

The Prescription Treatment® 388B Advance® Ant Gel Bait contains a slow acting borate active ingredient, and our previous studies revealed that it took 6 to 8 weeks to eliminate all members of a small OHA laboratory colony or indoor populations in homes. Hence, we weren't surprised that the OHA outdoor population reductions were slower with Prescription Treatment® 388B Advance® Ant Gel Bait than with Optigard™ Ant Gel Bait. At 2 wks after baiting cracks and crevices with Prescription Treatment® 388B Advance® Ant Gel Bait, outdoor OHA numbers were reduced by 69%, the highest reduction that occurred with this bait. Reductions dropped to 35% by week 4 and did not improve, even with re-baiting, until after the control populations started to naturally decline on the last reading date, week 11, September 26. Upon completion of the study we learned that at least one homeowner had been wiping down OHA trails to the baits and hence had not followed the study protocol. We had explained that this was OK before the study started, but to not interfere with foraging trails once baiting was initiated. An experimental version of the Prescription Treatment® 388B Advance® Ant Gel Bait t performed much better in the lab and in a previous field study (Vail et al. 2003 and unpublished data).

Slightly more indoor ant activity was found in the Advance®-treated houses than the Optigard™-treated ones. One Optigard™-treated house had greater than 10 ants indoors on week 4, at which time we re-baited. One Advance®-treated house had greater than 10 ants indoors on weeks 7 and 8. More than

10 ants were not seen inside on any other day. We've found that homeowners are willing to tolerate up to 10 ants seen inside on any given day. With this in mind, it appears that all treatments in study B were successful.

References

Vail, K. M., D. Bailey, and M. McGinnis. 2003. Perimeter Spray and Bait Combo. Pest Control Technology 31(7): 96-100.

URBAN PEST MANAGEMENT STRATEGIES FOR ARGENTINE ANTS

John H. Klotz[1], Michael K. Rust[1], Herb C. Field[2], Les Greenberg[1], and Ken Kupfer[3]
[1]University of California, Riverside, CA
[2]Lloyd Pest Control, San Diego, CA
[3]KM AntPro LLC, Nokomis, FL

The efficacy of various treatments to control Argentine ants, *Linepithema humile*, around homes in Riverside, CA, was evaluated over two seasons (July 2006 and 2007). The first season's field trials compared the efficacy of baits and contact insecticides applied alone and in various combinations around homes to control Argentine ants. Six exterior treatments were evaluated:

(1) Perimeter spray with Termidor® SC (0.06% fipronil): 3-4 gallons applied with a backpack sprayer (Birchmeier Co., Switzerland) along the foundation (one foot up and one foot out), around door and window frames, and to ant nests and trails along the edges of the sidewalks and driveway.
(2) Combination of Treatment #1 + Talstar® EZ Granules (0.2% bifenthrin) broadcast at 2.3 pounds per 1,000 square feet to foliage outside the Termidor® spray zone.
(3) Spot treatment with Termidor® SC: 1 gallon applied with a backpack sprayer to outdoor areas with trailing ants.
(4) Combination of Treatment #1 + Cy-Kick® CS (0.004% cyfluthrin) power-sprayed at 5-10 gallons per 1,000 square feet to foliage outside the Termidor® spray zone.
(5) Gourmet Liquid Ant Bait (1% disodium octaborate tetrahydrate) delivered in KM AntPro® Bait Stations (Nokomis, FL) (4-6 stations, each containing 12 ounces of bait) placed around the outside perimeter of each house.
(6) Combination of Treatment #1 + Treatment #5.
(7) Untreated control.

In the second season, we selected the most effective strategies from season one (see #1-3 above) and compared them with a new experimental bait containing imidacloprid (Vitis™) and a bifenthrin perimeter spray (Talstar® One):

(4') Vitis™ (0.001% imidacloprid) liquid bait delivered in KM AntPro® bait stations (6-7 stations, each containing 16 ounces of bait) placed around the outside perimeter of the house and in the yard.
(5') Perimeter spray with Talstar® One (0.06% bifenthrin): 3-4 gallons applied with a backpack sprayer (Birchmeier Co.) along the foundation (one foot up and one foot out), around door and window frames, and to ant nests and trails along the edges of the sidewalks and driveway.
(6') Untreated control.

Each treatment was applied at five homes and monitored periodically for efficacy. Efficacy was based on the percent population reduction in Argentine ants compared to pre-treatment numbers. The monitoring of ant population levels was conducted with conical vials containing 25% sucrose water, ten placed near the structure and ten placed away from the structure. Vials were filled with 13 ml of sucrose water, and the amount consumed over 24 hours was converted to ant visits by dividing by 0.3 mg, which is the average amount of sucrose water that one ant consumes per visit. Monitoring was conducted before treatments were applied and at various time intervals thereafter.

For comparison, five untreated control sites also were monitored each season. Unlike the treated homes described above, the control sites had light infestations with far fewer numbers of Argentine ants. These sites lacked outdoor pets, vegetation with hemipteran pests, and conditions conducive to Argentine ants.

All of the treatments significantly reduced Argentine ant activity over the course of the 8-wk studies during both seasons (see Table 1 & 2). The greatest reductions were achieved at homes that were treated with fipronil (Termidor®), and the best overall performance was when fipronil was combined with a broadcast of bifenthrin granules (Talstar®) (Treatment #2).

Table 1. Argentine ant activity[a] around residences in Riverside, CA, before and after exterior treatments[b] (N = 5 homes/treatment). Untreated controls (#7) are shown for comparison. From Klotz et al. (2007).

Treatment	Monitoring site[c]	Avg. number ant visits per vial (% reduction in ant counts[d]) at week after treatment				
		0	1	2	4	8
(1) Termidor® perimeter spray	Near Away	26,653 31,120	1,846 (93) 16,740 (46)	1,254 (95) 21,160 (32)	414 (98) 16,883 (46)	5,072 (81) 20,123 (65)
(2) Termidor® perimeter spray + Talstar® granules	Near Away	33,160 34,392	1,223 (96) 9,085 (74)	6,226 (81) 17,219 (50)	2,511 (92) 9,585 (72)	3,247 (90) 14,414 (58)
(3) Termidor® spot	Near Away	29,548 34,635	20,792 (30) 19,355 (44)	19,621 (34) 22,991 (34)	4,130 (86) 14,210 (59)	3,024 (90) 20,703 (40)
(4) Termidor® perimeter spray + CyKick® powerspray	Near Away	28,852 32,948	8,181 (72) 18,470 (44)	18,382 (36) 25,842 (22)	9,611 (67) 18,190 (45)	16,947 (41) 20,994 (36)
(5) Gourmet bait	Near Away	25,036 28,822	11,319 (55) 23,933 (17)	14,462 (42) 33,258 (0)	13,949 (44) 18,352 (36)	10,434 (58) 26,509 (8)
(6) Termidor® perimeter spray + Gourmet bait	Near Away	26,068 30,107	5,638 (78) 17,484 (42)	13,249 (49) 23,710 (21)	3,587 (86) 14,953 (50)	5,042 (75) 12,680 (58)
(7) Untreated	----[e]	7,996	3,513 (56)	4,253 (47)	3,919 (51)	1,839 (77)

[a] At each residence, ants were monitored at 20 conical vials, each containing 13 ml of 25% sucrose water. The amount of sucrose water consumed during a 24-hour period was converted to ant visits by dividing by 0.3 mg, which is the average amount that one ant consumes per visit.

[b] Treatments installed in July 2006.

[c] At each residence, 10 vials with sugar water were positioned near the structure, and 10 vials were positioned away from the structure.

[d] Adjusted for missing or spilled vials. Reduction based on pre-count numbers.

[e] At the untreated residences, monitoring sites were not categorized as near or away from the structure.

Table 2. Argentine ant activity[a] around residences in Riverside, CA, before and after exterior treatments[b] (N = 5 homes/treatment). Untreated controls (#6) are shown for comparison. From Klotz et al. (2008).

Treatment	Monitoring site[c]	Avg. number ant visits per vial (% reduction in ant counts[d]) at week after treatment				
		0	1	2	4	8
(1) Termidor® perimeter spray	Near Away	33,147 34,529	1,099 (97) 10,930 (68)	1,902 (94) 14,478 (58)	2,502 (93) 10,267 (70)	7,601 (77) 22,380 (35)
(2) Termidor® perimeter spray + Talstar® granules	Near Away	22,296 33,070	2,211 (90) 7,769 (77)	537 (98) 8,129 (75)	2,780 (88) 9,988 (70)	1,488 (93) 11,728 (65)
(3) Termidor® spot	Near Away	18,964 24,126	7,691 (59) 12,900 (47)	6,704 (65) 12,928 (46)	7,198 (62) 9,327 (61)	10,196 (46) 17,413 (28)
(4') Vitis™ bait	Near Away	22,547 28,749	3,775 (83) 12,865 (55)	4,626 (80) 13,198 (54)	3,897 (83) 10,425 (64)	12,938 (43) 23,133 (20)
(5') Talstar® perimeter spray	Near Away	24,416 33,015	4,531 (81) 16,019 (52)	4,179 (83) 16,898 (49)	7,192 (71) 23,269 (30)	7,068 (71) 25,224 (24)
(6') Untreated	Near Away	14,296 17,946	10,841 (24) 18,628 (0)	17,749 (0) 16,623 (7)	13,996 (2) 15,283 (15)	13,815 (3) 24,652 (0)

[a] At each residence, ants were monitored at 20 conical vials, each containing 13 ml of 25% sucrose water. The amount of sucrose water consumed during a 24-hour period was converted to ant visits by dividing by 0.3 mg, which is the average amount that one ant consumes per visit.

[b] Treatments installed in July 2007.

[c] At each residence, 10 vials with sugar water were positioned near the structure, and 10 vials were positioned away from the structure.

[d] Adjusted for missing or spilled vials. Reduction based on pre-count numbers.

In the second season, the fipronil spot treatment (#3) did not provide the same level of control as in the first season, although it significantly reduced ant activity. Over the course of the 8-week study, the bifenthrin perimeter spray (Treatment # 5') was consistently less effective than fipronil. The imidacloprid bait (Vitis™) (Treatment #4') attained >80% reduction after one month. Its subsequent loss of efficacy in week 8 was probably due to an insufficient amount of bait available to the ants during the month-long interval from the final refilling of bait stations at the 4-week inspection.

References

Klotz, J. H., M. K. Rust, L. Greenberg, H. C. Field, and K. Kupfer. 2007. An evaluation of several urban pest management strategies to control Argentine ants (Hymenoptera: Formicidae). Sociobiology 50: 391-398.

Klotz, J. H., M. K. Rust, L. Greenberg, H. C. Field, and K. Kupfer. 2008. Controlling Argentine ants in residential settings (Hymenoptera: Formicidae). Sociobiology 51: 579-588.

A LONGITUDINAL STUDY OF *CAMPONOTUS PENNSYLVANICUS* (HYMENOPTERA: FORMICIDAE) POPULATION STRUCTURE: A PRELIMINARY REPORT

Tracie M. Jenkins, Tyler D. Eaton, and Dan Suiter
The University of Georgia, Griffin Campus, Griffin, GA

Camponotus species are serious pests (Dukes 1989) that cause billions of dollars in wood damage annually in the United States. Unlike termites, they do not eat wood but rather exclusively excavate and nest in it. The black carpenter ant, *Camponotus pennsylvanicus* (DeGeer), is a prevalent structural pest of the eastern and central United States; it is the most common carpenter ant pest (Hansen and Klotz 2005) east of the Mississippi River. These ants prefer to excavate moist wood, but they will establish primary or satellite colonies in dry, sound wood throughout a structure such as in support timbers, window framing and sills, roofs, studs, shingles, and garages (Hansen and Klotz 2005). Building trends in the United States, which include building in or near forested areas, favor *C. pennsylvanicus* infestations (Akre et al. 1994). Other trends such as the growing urbanization in the southeastern United States and ecological changes due to warming trends are also exacerbating the problem of *C. pennsylvanicus* infestations.

This ant's economic importance, adaptability and the human propensity for building near forested areas where *C. pennsylvanicus* infestations are likely to occur make understanding carpenter ant genetic structure imperative if we are to draw correct conclusions from efficacy testing and develop effective management strategies. We, therefore, present preliminary data from an integrated morphology, ecology, behavior, and DNA marker technology study (Forschler and Jenkins 1999). These data will form the basis of a longitudinal research project designed to determine *C. pennsylvanicus* colony site fidelity, intra- and intercolony genetic structure, as well as spatial and temporal gene flow.

Twenty colony sites were identified in Griffin, GA. Twenty individuals from each colony were sampled and the COI (cytochrome oxidase I) gene was sequenced from all samples. Individual sequences from each colony formed consensus contigs. When the COI mitotype was the same for multiple colonies, a second and sometimes a third mtDNA gene was sequenced to verify the mitotype. Individuals from different colonies that shared the same mitotype were subjected to agonism studies in order to verify site fidelity and colony uniqueness. Since ants from the same colony do not fight, ants that fought were determined to be from different colonies even though the mitotypes were the same. In this presentation, we discuss the implications of our recent results and delineate the reasoning for the study's protocol, objectives, and long-term goals.

References

Akre, R. D., L. D. Hansen, and E. A. Myhre. 1994. Finding the parent colony, p. 115. *In* W. H. Robinson [ed.], Proceedings of the National Conference on Urban Entomology. Virginia Polytechnic Institute and State University, Blacksburg.

Dukes, J. 1989. Aspects of the biology, behavior, and economic importance of *Camponotus pennsylvanicus* (DeGeer) and *Camponotus ferrugineus* (Fabricius) (Hymenoptera: Formicidae). M. S. Thesis, Virginia Polytechnic Institute and State University, Blacksburg.

Forschler, B. T., and T. M. Jenkins. 1999. Evaluation of subterranean termite biology using genetic, chemotaxonomic, and morphometric markers and ecological data: A testimonial for multi-disciplinary efforts. Trends Entomol. 2: 71-80.

Hansen, L. D., and J. H. Klotz. 2005. Carpenter ants of the United States and Canada. Comstock Publishing Assoc., Ithaca, NY.

INDOXACARB AS A MANAGEMENT TOOL FOR CARPENTER ANTS

Laurel D. Hansen
Biology Department, Spokane Falls Community College, Spokane, WA

Carpenter ants (*Camponotus* spp.) are major structural pests because they excavate wood for nests. These ants are particularly important in the northern tier of states and southern Canada, especially where trees have been planted in landscaping in urban areas. Management tools include both baits and perimeter sprays. The new chemistry found in indoxacarb was tested in the form of containerized bait (Advion® Ant Bait Arena [0.1% indoxacarb)], a bait gel (Advion® Ant Gel [0.05% indoxacarb]), and a perimeter spray (indoxacarb 20 WG [0.05% and 0.10% indoxacarb]). Tests included (1) laboratory tests for efficacy and comparison with other commercial containerized and gel baits, (2) field applications of baits, and (3) laboratory trials for efficacy and residual activity as a perimeter spray.

Laboratory Efficacy Tests

Baits were tested in the laboratory with small colonies of 100 carpenter ants (*Camponotus modoc*) in plastic vented dishes. Baits tested included Advion® Arena, Advion® Gel, Prescription Treatment® Advance® 360A (0.011% Abamectin B_1) (container), Maxforce® FC (0.01% fipronil) (container), and Maxforce® Carpenter Ant Bait Gel (0.001% fipronil). Honey was used as the control. All treatments were replicated five times. Colonies were monitored at 6, 12, 24 hrs and daily through 11 days and average mortality of carpenter ants is shown in Table 1. Both of the indoxacarb bait formulations showed efficacy in laboratory trials.

Table 1. Average percent mortality of carpenter ants (*Camponotus modoc*) at various observation times when exposed to five bait formulations in laboratory feeding trials.

Treatment	12 hrs	24 hrs	2 days	3 days	4 days	5 days	6 days	7 days	11 days
Advion® Arena (container)	0.6	1	90	100					
Advion® Gel	5.4	86	90.4	98.2	100				
Advance® 360A (container)	1.2	2	8.6	24.2	37.6	63.2	76	90.2	99.8
Maxforce® FC (container)	3.8	85.2	100						
Maxforce® Gel	1.8	6.6	74.6	97.6	99.2	100			
Control	0.4	0.4	0.6	0.6	0.8	1	1	1.4	1.6

Field Tests

In 2006 and 2007, twenty-six field sites infested with *Camponotus* spp. were baited with Advion® Arena, Advion® Gel, or Maxforce® Carpenter Ant Bait Gel. Sites were evaluated weekly and at the end of the season by observing ants around the perimeter and on foraging trails. Control was measured by the number of ants observed in field inspections and by interviewing homeowners. Evaluations were determined as follows: (1) complete control (no ants observed), (2) decline in ant numbers (75%-90% as compared to pre-treatment numbers), or (3) lack of control (less than 75% compared to pre-treatment numbers). An alternative treatment was applied when numbers indicated less than 75% control. Table 2 gives a summary of control at field sites at the end of the season.

Table 2. Summary of field test sites and results with application of one of three baits for infestations of carpenter ants in 2006 and 2007.

Bait	No. sites	Species	Control[a] for all species/sites
Advion® Arena	4	*C. vicinus*	56% complete 22% decline 22% ATR
	5	*C. modoc*	
Advion® Gel	4	*C.modoc*	75% complete 25% ATR
	3	*C. vicinus*	
	1	*C. essigi*	
Maxforce® Carpenter Ant Bait Gel	2	*C. vicinus*	56% complete
	7	*C. modoc*	44% ATR

[a] Control was measured by the number of ants observed in field inspections and by interviewing homeowners: complete control = no ants observed, decline = 75%-90% compared to pre-treatment numbers, ATR = alternative treatment required (<75% compared to pre-treatment numbers).

Perimeter Spray Tests

Efficacy and residual activity of spray applications of indoxacarb 20 WG at two concentrations (0.05% and 0.10%), a standard (Termidor® SC [0.06% fipronil]), and a control (water) were tested by exposing ants to treated wood and then aging the treated wood in a natural environment protected from direct sunlight and rainfall. Each unfinished wood (pine) board (12” x 12” x 2”) was sprayed with 15 mL and allowed to dry. The bottom of a plastic petri dish containing 20-24 ants was inverted onto the treated surface and ants were allowed to walk on the treated surface for 1 min, 10 min, or 24 hrs. Following the timed exposure, ants were collected and numbers were recorded. Honey and water were supplied and mortality was monitored daily for 7 days following this exposure and again at 12 days.

Treated boards were placed in a natural environment and protected from direct sunlight and rainfall with a wood cover (24 “x 24” x ¼”) suspended over the treated surface. Ants were exposed as described above (day 0) and again after 7, 30, and 60 days to determine residual activity. All tests were replicated five times.

Table 3 shows the average percent mortality for all testing periods for all treatments. Efficacy and residual tests with indoxacarb 20 WG used as a perimeter spray on wood substrates showed 100% mortality with 10 min exposures through 60 days following the initial spray application.

Table 3. Average percent mortality of carpenter ants after various exposure times (1 min, 10 min, 24 hr) with unaged (0 day) and aged residues (7, 30, 60 days after spray application [DAT]) of indoxacarb, fipronil, or water (control) treatments.

Indoxacarb 20 WG at 0.05%

	1 min exposure DAYS					10 min exposure DAYS					24 hr exposure DAYS				
DAT	2	3	4	6	12	2	3	4	6	12	2	3	4	6	12
0	38	74	79	92	96	60	61	81	92	100	100	100	100	100	100
7	24	45	61	83	95	19	83	98	98	100	100	100	100	100	100
30	6	14	30	40	54	24	54	69	83	98	92	100	100	100	100
60	3	3	5	6	14	10	22	27	53	69	89	98	99	100	100

Indoxacarb 20 WG at 0.10%

	DAYS					DAYS					DAYS				
DAT	2	3	4	6	12	2	3	4	6	12	2	3	4	6	12
0	69	80	80	97	100	85	91	96	99	100	100	100	100	100	100
7	40	64	95	96	98	67	96	99	99	100	100	100	100	100	100
30	21	32	49	66	87	68	81	93	96	99	100	100	100	100	100
60	1	11	36	62	93	20	54	74	86	100	96	100	100	100	100

Termidor® SC at 0.06%

	DAYS					DAYS					DAYS				
DAT	2	3	4	6	12	2	3	4	6	12	2	3	4	6	12
0	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
7	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
30	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
60	98	100	100	100	100	100	100	100	100	100	100	100	100	100	100

Untreated/water controls

	DAYS					DAYS					DAYS				
DAT	2	3	4	6	12	2	3	4	6	12	2	3	4	6	12
0	0	0	0	0	0	0	0	0	1	2	1	3	5	6	12
7	1	1	2	2	4	0	0	0	0	1	0	0	1	1	1
30	3	4	4	4	4	1	1	1	1	2	0	0	0	1	2
60	0	0	0	2	2	1	1	1	1	1	1	1	1	1	1

HORIZONTAL TRANSFER OF INDOXACARB IN THE GERMAN COCKROACH: TROPHIC CASCADE RESULTS IN TERTIARY KILL

Grzesiek Buczkowski[1], Clay Scherer[2], and Gary Bennett[1]
[1] Department of Entomology, Purdue University, West Lafayette, IN
[2] DuPont Professional Products, Wilmington, DE

Horizontal transfer of indoxacarb in the German cockroach, *Blattella germanica,* was examined under laboratory conditions. Results showed that a single bait-fed adult cockroach (i.e., the donor) transferred indoxacarb to numerous primary recipients (secondary mortality), which then became secondary donors. The primary recipients subsequently became donors to other cockroaches and caused significant mortality in other members of the aggregation resulting in tertiary kill. Indoxacarb was effectively transferred among adult cockroaches and resulted in significant secondary mortality. When adult males served as donors and vectored the insecticide to adult males, the donor:recipient ratio affected the mortality of the recipients and the rate of secondary mortality increased with increasing the ratio of donors to recipients. Furthermore, secondary mortality in the untreated cockroaches was significantly affected by the freshness of excretions from the donors, the presence of alternative food, and the duration of contact between the donors and the recipients. Ingested indoxacarb was most effectively translocated when the recipients interacted with freshly symptomatic donors in the absence of alternative food. The transfer of indoxacarb continued beyond secondary mortality and resulted in significant tertiary mortality. Excretions from a single bait-fed adult killed 38/50 (76%) nymphs within 72 h. The dead nymphs then vectored indoxacarb to 20 adult males and killed 16/20 (81%) recipients within 72 h. Behavioral mechanisms involved in the horizontal transfer of indoxacarb may include: necrophagy, emetophagy, and ingestion of other excretions that originate from the donors.

DEVELOPING AN AFRICANIZED HONEY BEE EMERGENCY MANAGEMENT EDUCATION PROGRAM FOR FLORIDA

William H. Kern, Jr.
Ft. Lauderdale Research and Education Center, University of Florida, Davie, FL

As early as 2002, the Africanized honey bee hybrids (AHB), *Apis mellifera scutellata* (Hymenoptera: Apidae), were intercepted in Florida around the deep water ports of Tampa, Miami, and Ft. Lauderdale (Port Everglades). In 2005, feral colonies were found inland of the ports, which prompted the Florida Dept. of Agriculture and Consumer Services to declare AHB established in Florida. It was apparent from news reports that AHB training for first responders was needed immediately.

<u>Goals of Extension Education Program for First-responders</u>

1. Keep first-responders safe while responding to a stinging emergency. Emphasize the need and use of Personal Protection Equipment (PPE).
2. Understand why AHB can be potentially more dangerous than EHB (European honey bees).
3. Explain and demonstrate rescue tactics and techniques.
4. Explain why elimination of the defensive colony is essential for public safety despite concerns over loss of managed EHB colonies to Colony Collapse Disorder.

Bee Sting Threat Triage

1. Victim or victims being stung and unable to escape the bees. (Life Threatening Emergency)
2. Agitated colony resulted in victims being stung, but victims escaped into vehicle or structure. Victims may need evacuation or treatment. (Possible Emergency)
3. Colony present close to where people are working. (Potential Emergency)
4. Colony present on property. (Not an emergency). Call a trained PMP.
5. Swarm present on property. (Not an emergency). Call a trained PMP.

What should the 911 operator ask in response to the following call? "I have a swarm, colony, nest, or hive of bees in my yard or on my house!"

1. Is someone being stung or attacked right now and can't escape the bees?
2. Is someone trapped in a vehicle or structure by angry bees?
3. Has someone been stung and needs transportation to the hospital?
4. If **NO** to questions 1-3, then it is not an emergency. They need to call a licensed Pest Management Professional to remove the bees. If the colony is on government property, inform the appropriate government officials.

Testing has shown that Class A foam was effective at neutralizing bees at 2% and 5% concentrations, while Class B foam required ≥5 % to kill honey bees within 60 seconds. A uniform recommendation of ≥5% concentration of Class A, Class B, or AFFF foaming agent is being given to decrease confusion. Usually we attempt to conduct live training activities with AHB colonies if the training takes place at the Ft. Lauderdale Research and Education Center. This helps the firefighters experience AHBs in a controllable environment and gain confidence in their PPE and tactics.

The result of this program is almost complete acceptance of using foam for rescues and agitated AHB colony control by Florida fire/rescue departments. Additional information on this and other Florida Extension AHB programs can be found at http://afbee.ifas.ufl.edu.

SYMPOSIUM

GLIMPSE OF NOVEL CHEMISTRY/ TECHNOLOGY IN TERMITE MANAGEMENT

20 May 2008

Organizer:
Shripat T. Kamble (University of Nebraska)

CHLORANTRANILIPROLE: EXCITING NEW CHEMISTRY FROM DUPONT™ FOR TERMITE CONTROL: MODE OF ACTION AND POTENTIAL AS A TERMITICIDE

Clay Scherer and Mark Coffelt
DuPont Corporation, Newark, DE

Insecticides with new modes of action reach the commercial market infrequently. DuPont has recently developed a new insecticide, chlorantraniliprole, which exhibits a novel mode of action and has demonstrated specific effectiveness against subterranean termites. Chlorantraniliprole is the first anthranilic diamide compound within the diamide class of insecticides. Chlorantraniliprole binds to ryanodine receptors in muscle cells causing uncontrolled release and depletion of calcium stores preventing further muscle contraction. Structural differences within insect ryanodine receptors and mammalian ryanodine receptors provides for remarkable selectivity and exceptionally low mammalian toxicity. Additional features of this new chemistry and a summary of termite efficacy laboratory studies are discussed.

TRANSPORT® TERMITICIDE INSECTICIDE: NEW CHEMISTRY FOR TERMITE CONTROL

Dina Richman and James Ballard
FMC Professional Solutions, Philadelphia, PA

More than 200 termite-infested structures were treated between 2005 and 2007 with a 50 WP water-soluble bag formulation of Transport® Termiticide Insecticide (acetamiprid + bifenthrin; 0.11% dilution). The termites were cleared from the structures within an average of 30 days. Once the product was registered in 2007, an additional 20 structures were treated to demonstrate the efficacy of the product. In these tests, the termites were cleared from the structures within an average of 26 days. Another

formulation of Transport®, designated F5688 11% ME, is also being developed for use in in-line injector systems. Laboratory comparison of the two formulations indicated little difference in LT100 when *Reticulitermes flavipes* and *Coptotermes formosanus* were sprayed directly with the finished 0.11% dilution. When the termites were forced to contact soil treated at the labeled rate, the ME formulation had a lower LT100 than the WP formulation. Field tests are planned for late 2008.

LUFENURON TERMITE BAIT

Clark Lovelady[1], David Cox[2], Mark Zajac[3], and Bob Cartwright[4]
[1]Syngenta BR&D, Vero Beach, FL
[2]Syngenta BR&D, Madera, CA
[3]Syngenta Professional Pest Management, Greensboro, NC
[4]Syngenta Professional Pest Management, Dallas, TX

The objective of this paper is to review the lufenuron termite bait developed by Syngenta. Lufenuron is a benzoylurea compound that acts as an insect growth regulator by interfering with the polymerization, synthesis, and deposition of chitin in the insect. The termite bait is a cardboard matrix that is loaded at a rate of 1500 ppm lufenuron. Lufenuron is currently registered in the United States as an oral flea treatment and outside of the United States on multiple crops and pests. Two aspects of the lufenuron termite bait program are covered here: field research plots and a national structural Experimental Use Permit (EUP) program.

The objective of the field plot research study was to establish a cause and effect of the lufenuron bait against subterranean termites. These field research plots were established across the U.S. using independent investigators. To document ongoing termite population activity at each study site, independent termite monitors were established. A determination was made as to whether single or multiple colonies of termites were feeding at those monitors using the following methods: mark and recapture techniques, genetic analyses, and behavioral determination. Each study site (investigator) required a minimum of a control and a treated colony to conduct the test. Ideally, 3 treated colonies and 1-2 control colonies were needed. In addition, the investigators determined the amount of feeding (consumption) at each monitor. For those monitor stations with activity, the station was either baited or used as independent monitors. To fulfill U.S. Environmental Protection Agency (EPA) regulatory guidelines, termites should be suppressed (75% reduction in activity) within 12 months from the time of bait insertion. The monitors (baited and unbaited) were inspected monthly, recording both consumption and activity. Two of the field plot studies are reviewed here.

Dr. Susan Jones of Ohio State University established four *Reticulitermes flavipes* colony sites in Columbus, OH. Termites infested the monitor stations at the four sites within one month of installation (average 38% infestation rate). Termites readily consumed the lufenuron bait placed in three of the colony sites. Bait consumption among the treated colonies was 27 to 127 grams per colony. Baited termites were eliminated within 3.5 – 10.5 months across the sites.

Dr. Mike Haverty, of the USDA Forest Service (Berkeley, CA), established 12 *Reticulitermes hesperus* colony sites in Placerville, CA. Six termite colonies were baited in this study and activity ceased within an average of 70 days of baiting (51- 93 d range). The bait consumption in these colonies averaged between 7 to 9 grams per colony. The wood consumption in the independent monitors in the baited colonies ceased. Two monitors in the baited colony area became active after the bait was removed, but genetic analysis confirmed these "newly arriving" termites were not from the original colony. Six non-baited colonies remained active as evidenced by continuing to consume wood in the independent monitors.

A large multi-site study was undertaken, in partnership with Landis International and local pest management professionals (PMPs), to provide structural efficacy data for the lufenuron termite bait. This study was conducted under an EUP granted by EPA and employed procedures accepted as Good Laboratory Practice (GLP). The structures were located in all of the major termite regions across the U.S. (22 states). The termite infestation in each of the enrolled structures had the infestation characterized and verified via the collection of live termites for archiving and DNA analysis if necessary. Monitoring stations were placed around the structures at 10-15 foot intervals and in areas with conducive conditions. The stations were inspected once a month for termite activity. If activity was detected, the monitor device was replaced with the lufenuron bait device. The inspections of the monitors and the baited stations continued on a monthly interval. At the time of inspection, if a bait device had 50% or more consumed, it was replaced. Once termite activity ceased in the baited stations, they were replaced with monitoring devices. After activity ceased in the monitors and baited stations, the structure was re-inspected for termite activity. If the structure was free of termites, it was re-inspected 12 months later to demonstrate an absence of termites in the building for 1 year (regulatory benchmark).

Of ~100 enrolled structures in the national structural EUP program, termites were eliminated from 78 structures. Of these 78 structures, 55 have been free of termites for 1 year or more after the initial elimination (2^{nd} re-inspection). The other structures have not matured beyond the 1 year mark after termite elimination or data have not been received. Another five homes were cancelled before the 1-year post-elimination inspection could be conducted due to such factors as Hurricane Katrina, move outs, loss of homeowner cooperation, etc.

The general conclusions from the work performed on the lufenuron termite bait is that it is effective against subterranean termites as demonstrated in field plots across the U.S. and a structural EUP program in 22 states across the major termite regions.

SENSE MAKES CENTS: HOW HALO™ AND ESP™ SENSORY TECHNOLOGIES ARE REVOLUTIONIZING THE TERMITE MARKET

Marc Fisher and Matt Messenger
Dow AgroSciences, Indianapolis, IN

ESP™ (Electronic Sensing Protection) Technology is a cutting-edge tool developed by Dow AgroSciences to add labor-saving value to its existing termite baiting and monitoring products. Research has shown that ESP™ is effective at indicating termite activity and is durable in the natural environment. Market analysis has likewise demonstrated that using ESP™ provides important cost-savings to pest management professionals (PMPs).

Halo™ Detection leverages existing Sentricon® with ESP™ Technology, and represents a unique electronic subterranean termite monitoring-only product for PMPs that can be useful in integrated pest management programs. Halo™ Detection was proven effective in identifying subterranean termite activity in soil around un-infested and infested sites across the U.S. The transition from Halo™ Detection to a termite baiting system, such as the Sentricon® Termite Colony Elimination System, was successful in field trials in eliminating colonies of economically important subterranean termites.

This presentation reviews the impact of these two new technologies from a scientific and economic standpoint.

FASTOUT™ CS FOAM – INTRODUCTION AND EFFICACY REVIEW OF THE FIRST NON-REPELLENT READY-TO-USE BROAD-SPECTRUM MICRO-ENCAPSULATED PYRETHROID FOAM FORMULATION

James Cink, Jonathan Berger, Kyle Jordan, and Steven Sims
Whitmire Micro-Gen, St. Louis, MO

FASTOUT™ CS FOAM is a ready-to-use pressurized foam formulation containing microencapsulated 0.1% cyfluthrin, a pyrethroid insecticide. In contrast to the insect repellency shown by many pyrethroids, FASTOUT™ CS FOAM has demonstrated, through repeated laboratory bioassay studies, non-repellent action towards a variety of insects. It also has consistently demonstrated the rapid control expected from pyrethroid insecticides. Results of choice and no-choice bioassays with FASTOUT™ CS FOAM against several species of termites and ants are discussed.

In no-choice bioassays involving 72 h exposure to surfaces treated with FASTOUT™ CS FOAM, mortality of the eastern subterranean termite (*Reticulitermes flavipes*) and the Formosan subterranean termite (*Coptotermes formosanus*) was 100% and 99%, respectively. Application of the foam formulation without the active ingredient resulted in mortalities of less than 8% for both termite species. Similar mortality rates for treatments and controls were seen in choice bioassay studies involving these two termite species. When tested using a choice laboratory bioassay method involving the southeastern drywood termite (*Incisitermes snyderi*) FASTOUT™ CS FOAM provided 100% control in less than 25 d compared to Premise® Foam (0.05% imidacloprid), which caused only 65% mortality after 46 d. In a choice bioassay study involving the Argentine ant (*Linepithema humile*), FASTOUT™ CS FOAM caused significantly greater mortality than Premise® Foam, with both of these insecticides causing significantly greater mortality than CB D-Foam™ (0.06% deltamethrin). In laboratory bioassays FASTOUT™ CS FOAM caused 100% mortality of carpenter ants (*Camponotus modoc*) within 1 h of exposure to a previously treated surface. In the same experiment, Premise® Foam caused only 78% mortality after 12 d. In a similar study, FASTOUT™ CS FOAM caused 100% mortality of *Camponotus pennsylvanicus* after 24 h whereas Premise® Foam caused only 64% mortality. In both choice and no-choice bioassays, FASTOUT™ CS FOAM clearly produced faster insect control, compared to either Premise® Foam or D-Foam™, and exhibited non-repellent characteristics.

GENE SILENCING AS A TOOL FOR TERMITE CONTROL?

Michael E. Scharf
Department of Entomology and Nematology, University of Florida, Gainesville, FL

Recent advances in molecular biology have made gene silencing in insects a reality. RNA interference (RNAi) is the primary tool available for this purpose. In termites, RNAi is a proven research tool that has begun to elucidate molecular mechanisms of termite sociality. However, while it is a proven research tool, the utility of RNAi as a tool for termite control remains to be fully realized. Perceived barriers include target identification, delivery strategies, safety to non-target organisms, and acceptance by the public and regulatory agencies. This presentation will overview recent successes, as well as provide a synopsis of currently perceived barriers.

INNOVATIONS AND NEW TECHNOLOGIES FOR MANAGEMENT OF SUBTERRANEAN TERMITES – WHO NEEDS THEM?

Nan-Yao Su
Department of Entomology & Nematology, Ft. Lauderdale Research & Education Center, University of Florida, Davie, FL

There are many parties that may become involved in termite control considerations, including property owners, real estate developers, building contractors, financial institutions, termite control applicators, manufacturers of control measures, federal or state regulators, researchers and extension agents. Each party has its own set of priorities. The priority for a homeowner whose house is currently infested by termites is the immediate remedy of the problem, but buyers of new houses, who ultimately pay the cost of pre-construction treatment or termite inspection, are usually unaware of potential termite problems. For a technology to be sustainable, it has to solve user's problems. One unique aspect of termite control industry is that termite control applicators, instead of the homeowners, are the "direct" users of these technologies. Homeowners who provide the financial basis for the technologies are "indirect" users, and their interests do not always dictate the development of new technologies. One example is the physical barrier such as the stainless steel mesh. Despite its ability to provide a better and safer barrier than most soil termiticides, very little has been used. With the development of baiting technologies that are capable of eliminating the subterranean termite colonies, there have been efforts to implement area-wide projects for population management of these cryptic pests. One challenge facing the area-wide projects is the involvement of termite control industry that is used to the business model of protecting individual homes under contract. Moreover, the goal of the area-wide projects to reduce termite damage potentials is not necessary the industry's business priority.

SYMPOSIUM

ASSESSMENT AND IMPLEMENTATION OF IPM IN SCHOOLS

20 May 2008

Organizers:
Dawn H. Gouge (University of Arizona), Tom Green (IPM Institute of North America, Inc.), and Alexandre V. Latchininsky (University of Wyoming)

NEW TOOL TO HELP SCHOOLS CALCULATE THE COSTS OF IPM

Michael E. Merchant[1], Blake Bennett[1], Janet A. Hurley[1], Kathy Murray[2], Belinda Messenger[3], Lawrence "Fudd" Graham[4], Faith Oi[5], and Rebecca Baldwin[5]
[1]Texas AgriLife Extension Service, Dallas, TX
[2]Maine Department of Agriculture, Portland, ME
[3]California Department of Pesticide Regulation, Sacramento, CA
[4]Auburn University, Auburn, AL
[5]University of Florida, Gainesville, FL

Integrated pest management (IPM) is frequently promoted as an effective means of reducing risks of both pests and pesticides in public school settings. Nevertheless, due to lack of standards, policies, or regulations requiring the use of IPM in most states, implementation of IPM among school districts has been slow.

A perception that implementing IPM costs more than conventional pest control may be one reason that IPM adoption among schools lags nationwide. However, a statewide survey of 554 school district IPM coordinators in Texas, where IPM is mandatory, showed that nearly 54% of respondents felt that IPM *reduced* their long-term cost of pest management. Results of the Texas survey showed that one of the least commonly adopted IPM practices among school districts was prioritizing building repair and maintenance needs (i.e., for pest proofing and sanitation improvements). Such costs are rarely considered in IPM cost-benefit analyses, yet are one of the most important considerations when designing an IPM program to reduce the need for pesticides.

A heuristic, Excel spreadsheet-based, decision tool was developed to project the probable costs of IPM. The IPM cost-calculator provides users with an estimate of overall pest risk of the school being evaluated, a facilities maintenance pest management budget, and a prioritized list of suggested facility improvements. The tool was demonstrated to approximately 84 Texas school districts in 2006-2007, and the pest risk function output was compared to subjective risk scores by experts in 11 school districts in Maine, Florida, Alabama, and California in 2007. Low correlation between the subjective ratings provided by experts and the calculator-generated risk ratings indicated that the calculator risk function may need further refinement. However, interest in the calculator as a budgeting and planning tool was high. Half of the surveyed maintenance administrators (n=8) said they were "highly likely" to use the calculator tool in their budgeting process.

ADVOCACY, POLICY, AND REGULATION

Janet A. Hurley
Texas AgriLife Extension Service, Dallas, TX

Currently there are thirteen states with some type of IPM law or rule, while six more states have a voluntary program in place. There has been much discussion and debate about Federal legislation to adopt IPM; however, to date there has been little movement in this direction. There is a difference between states that have a school IPM law and those states that have nothing. Learn how you can educate and implement IPM in your state with and without a law. Learn how to motivate a school community about IPM--it's easy and fun.

ASSESSMENT AND IMPLEMENTATION OF IPM IN SCHOOLS: PRACTICAL IMPLEMENTATION

Marc Lame
Indiana University, Bloomington, IN

When reviewing the literature regarding the implementation of public programs, it becomes apparent that three questions must be asked and answered to successfully implement a program such as IPM: 1) What action must to be taken?; 2) who will take the necessary action?; and 3) do those that are taking action have the resources to complete their mission (Starling 1998)?

What action must to be taken? The "action" needed to practically implement an integrated pest management (IPM) program in the school environment is to diffuse the incorporation of activities of the school community that prevent and/or address pest infestations in the most effective way possible. Further, that this action be in partnership with an objective pest management professional. These activities include school sanitation (cultural control), maintenance (cultural and mechanical control) and security (identification of invading or infesting pests – monitoring). When a pest infestation is documented these activities can be integrated with chemical control conducted by a qualified professional which includes a critical school activity – procurement. In other words, school communities must be allowed to believe they can successfully implement IPM by *"doing what they are doing now – just think pests".*

While many school communities have been made aware of the IPM innovation from information offered by change agents (through conferences, trade journals, the internet, etc.), few have verifiable and/or sustainable programs. Thus, this lack of adoption is more a result of failed implementation rather than unavailable pest management technologies or inadequate funding or concern for school occupant health by school officials. Failed implementation is often the result of the change agents not taking the adopting communities through the "innovation-decision" process to diffuse the IPM innovation. Thus, the "action", more specifically becomes implementing IPM by managing the process of adoption. *"IPM is a process not a miracle"*, it requires nurturing and confirmation to be diffused by the school community. If the IPM innovation has a relative advantage over an existing practice, is compatible with the community's norms, values and beliefs, and can be tried and observed, then it can be sustained by the adopting community. In other words, *"pest management is people management".*

Who will take the necessary action? In short, change agents. Historically, IPM change agents have been from University Extension (USDA) programs and/or State Lead Agencies which implement the Federal Insecticide, Fungicide, Rodenticide Act (U.S. Environmental Protection Agency [EPA]). Practically, Extension is minimally involved in school IPM (14% of states) and State Lead Agencies are taking more of a role. However, not-for-profit organizations (IPM Institute of NA, NEHA, Beyond Pesticides) currently are recognized change agents and recently health agencies are becoming increasingly involved (U.S. Centers for Disease Control and Prevention).

Do those that are taking action have the resources to complete their mission? Do those responsible for ensuring protection of the school from the risks of pests and pesticides provide job security and resources for implementers of IPM who attempt to change their community's behavior? There are no funded mandates for the implementation of school IPM in the U.S. Therefore, support for the IPM in Schools "initiative" is unfunded or underfunded. Three federal agencies are currently providing funding for the implementation (versus research) of IPM in schools – EPA, USDA and HHS.

Practical implementation of IPM in schools by change agents requires they must:

1. Use a successful model to demonstrate to the school community, the public, and policy makers that IPM has undeniable positive attributes and can easily overcome the pain of change.
2. Transfer it – make sense beyond the schools. The philosophy of IPM as practiced by most implementers (sometimes including me) has been too narrowly focused in the context of folks that work for our schools and entomology. The political base for IPM could be expanded by promoting IPM education to the public specific to school and home pest management, but with regard to a general awareness of public health and environmental concerns that could be adopted by all pesticide users (municipalities, work places, community centers, elderly and childcare, etc.).
3. Market it – creating partnerships. Management of public programs increasingly goes beyond mandates to marketing. Those responsible for policy decisions (children's health advocates, government regulators, school officials, professional pest managers, etc.), program development, and program implementation concerning pesticide use and pest management would do well to consider not only the importance of communication as a management skill, but also to employ the sub-specialty of diffusion into their strategic plans. Work with school business officials and the pest control industry to develop a "demand-side" (versus "supply-side) business model that is verifiable, sustainable, and profitable.

References

Starling, G. 1998. Managing the Public Sector, 5th ed. Harcourt Brace College Publishers, Austin, TX.

NATIONAL PEST MANAGEMENT STRATEGIC PLAN FOR IPM IN SCHOOLS

Tom Green[1] and Dawn H. Gouge[2]
[1]IPM Institute of North America, Inc., Madison, WI
[2]University of Arizona, Maricopa, AZ

Pest management practices in our nation's schools are in need of improvement. More than 50 published surveys and studies since 1994 have documented deficiencies including unmanaged pest infestations, unsafe and illegal use of pesticides, and unnecessary pesticide exposures to students, staff and visitors at schools. Improvement is feasible and affordable. Pest complaints and pesticide use in schools and other public buildings have been reduced by 71−93% through Integrated Pest Management (IPM), with no long-term increase in costs. In 2006, a working group was formed to develop a National Pest Management Strategic Plan for school IPM with a goal of achieving full implementation of IPM in all of our schools by 2015 (http://www.ipminstitute.org/school_ipm_pmsp.htm). The plan includes stakeholder-identified priorities for accelerating IPM adoption in schools, action steps and timeline, details on the current status of pest management in our school systems, and our current understanding of best practices. Ongoing objectives include meeting plan priorities, updating the plan on a regular basis, annual evaluation and progress reporting, and coordination by national and regional school IPM working groups.

REGIONAL WORKING GROUPS

Lawrence "Fudd" Graham[1] and Dawn H. Gouge[2]
[1]Auburn University, Auburn, AL
[2]University of Arizona, Maricopa, AZ

Pest Management Strategic Plans (PMSPs) have traditionally been associated with agriculture and crops. All PMSPs currently listed on the National IPM Center web site (http://www.impcenters.org/index.cfm) are for agricultural commodities. There is now a PMSP under development for the urban sector, the National Pest Management Strategic Plan for IPM in Schools.

Regional School IPM Work Groups have been formed with help from the Regional IPM Centers. The work groups were established to encourage collaboration between university, state agencies, federal agencies, industry, and advocacy groups working to encourage and enhance successful implementation of IPM in schools. The groups are dedicated to promoting the use and adoption of School Integrated Pest Management by:

- Setting goals and priorities that minimize and balance risks of pests and pest management strategies
- Collaborating and sharing resources with colleagues
- Identifying and pursuing resources together
- Producing and presenting new resources that are economically acceptable and practical

We strive to accomplish this through development of an inventory of programs and resources, increased networking and communication, improved access to and sharing of resources, and identification of IPM implementation challenges and barriers.

SUBMITTED PAPERS

POWDERPOST BEETLES, FORMOSAN TERMITES & OTHER NEW ORLEANS PESTS

20 May 2008

ANOBIID POWDERPOST BEETLES IN AN INFESTED CRAWL SPACE: RESULTS OF A TWO-YEAR STUDY

Daniel R. Suiter and Tyler D. Eaton
Department of Entomology, University of Georgia, Griffin, GA

We report the results of a two-year study (May 2006-May 2008) on the infestation dynamics and control of an anobiid powderpost beetle infestation in a structural crawl space in Griffin, GA. Environmental variables monitored during the study included wood moisture content and the relative humidity and temperature of the crawl space environment.

EFFECT OF PRECOCENES AND BIOGENIC AMINES ON FORMOSAN SUBTERRANEAN TERMITE SOLDIER FORMATION

Lixin Mao[1], Shuang-Lin Dong[1,2], and Gregg Henderson[1]
[1]Department of Entomology, Louisiana State University Agricultural Center, Baton Rouge, LA
[2]Key Laboratory of Monitoring and Management of Plant Diseases and Insects, Ministry of Agriculture, Nanjing Agricultural University, Nanjing 210095, China

Soldier caste development in termites involves a self-regulatory negative feedback mechanism once a specific proportion is achieved. That is, once there is an optimal ratio of soldiers, new soldier formation is inhibited. How and why soldiers possess the ability to inhibit worker-to-soldier transformation (soldier inhibitory factor) is unclear. What is known is that juvenile hormone (JH) plays an important role in this regulation. Higher JH levels induce soldier differentiation, and applications of JH or JH analogs (JHA) stimulate worker-to-soldier transformation. The presence of soldiers weakens the stimulatory effect of the applications of JH or JHA. The presence of soldiers also reduces the JH levels in workers and suppresses worker-to-soldier molts. However, chemicals known to inhibit soldier formation (anti-JH agents) are rare. In this laboratory study, two groups of compounds (precocenes and biogenic amines) with a known JH regulatory function in insects were tested for their effects on soldier caste formation in *Coptotermes formosanus* Shiraki.

Precocenes are one group of anti-juvenile agents that rarely has been evaluated. Testing concentrations included 10µg, 50µg and 100µg of precocene I and precocene II, and treated filter paper was provided to groups of 100 termite workers in Petri dishes. The results showed that precocene I at 100µg significantly delayed the formation of the first presoldier and the first soldier. Additionally, precocene I significantly reduced the soldier proportion at 40 days after treatment (DAT). In most insect models the mode of action of precocene I and precocene II is to damage the corpora allata (CA), thereby shutting down the production of JH. Our findings that precocene I inhibits soldier formation suggests that the CA may be the target site of the "soldier inhibitory factor". Understanding why precocene I has an inhibitory effect on termite soldier formation while precocene II does not may be revealing.

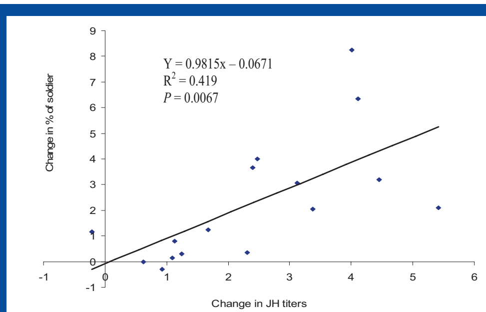
We also evaluated four biogenic amines (dopamine, octopamine, serotonin, and tyramine). These compounds are generally known to either decrease or increase JH levels depending on the insect species tested. However, our study found that these four biogenic amines at concentrations of 0.5µg, 100µg, and 1000µg had no effect on termite soldier formation. The observation that neurohormone applications did not affect termite soldier formation may reflect a reduced importance in their enhancement or suppression of JH synthesis in termites. However, our result also may reflect the limitations of the experimental design. For example, the range of concentrations that we tested may not have included the biogenic effective concentration. How the termite CA is impacted by neurohormones and anti-JH agents requires further study.

Effect of Anti Juvenile Hormone Agents and Biogenic Amines on Formosan Subterranean Termite Soldier Formation

Lixin Mao, Shuang-Lin Dong and Gregg Henderson
Department of Entomology
Louisiana State University AgCenter

Soldier Caste Regulation

- Soldier proportion is maintained at a specific level
- Soldiers inhibit new soldier formation
- Direct interaction required
- Juvenile hormone (JH) induces soldier formation
- Soldiers suppress worker JH



The relationship between changes of soldier proportions and worker JH levels Mao et al. 2005, Ann. Entomol. Soc. Am. 98:340-345

Anti-JH compounds: precocene I & II

- Can readily penetrate intact insects
- Migrate to corpora allata (CA)
- Damage CA cells
- Stop the production of JH

Hypothesis: preceocene I or II inhibits soldier differentiation

Concentrations: 10 ug, 50 ug, 100ug

Biogenic amines:
- Neuromodulators
- Regulate physiological processes
- Enhance or reduce JH

Hypothesis: Biogenic amines affect termite soldier differentiation

Dopamine, Octopamine, Serotonin and Tyramine
0.5 ug, 100ug, 1000ug

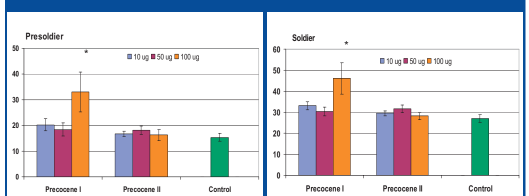
Materials and Methods

- 15x100 mm Petri dish
- Two filter papers, the top one was treated with chemicals
- 100 workers/dish
- 28°C incubator
- 2-3 termite groups
- 5 reps/treatment/group

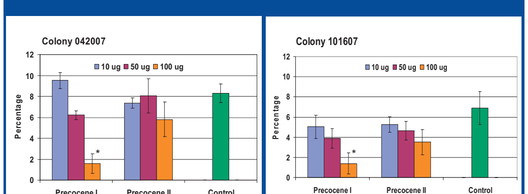
Data collection and analysis

- Number of days required for the first presoldier or soldier to appear
- Number of presoldiers, soldiers and workers at 40 days after treatment
- ANOVA
- Fisher's protected LSD

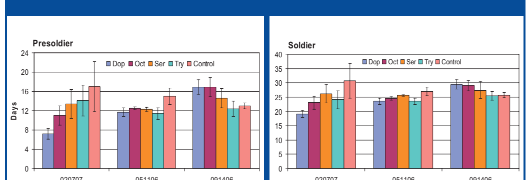
The number of days required for the first Presoldier and soldier formation of precocene treatments



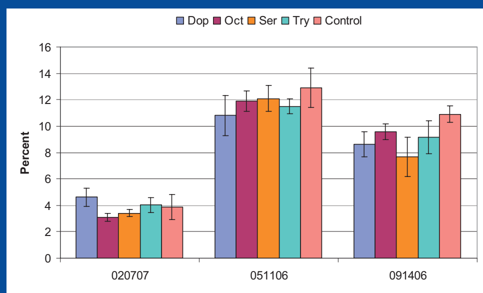
The soldier proportion of the two colonies at 40 days after precocene treatments



The number of days required for the first presoldier and soldier formation of biogenic amine treatments

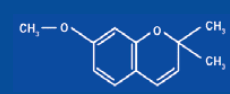


The soldier proportion at 40 days after biogenic amine treatments

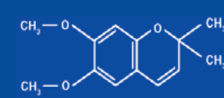


Discussion

- Precocenes are JH antagonist for many insect species
- Inhibit soldier formation for one drywood termite species
- Inhibit soldier formation for subterranean termites



Precocene I



Precocene II

Discussion

- Biogenic amines modify the effect of hormones in response to various stimuli
- Honey bee division of labor
- Enhance or reduce JH
- No effect on termite soldier differentiation

Acknowledgement

We would like to thank Ahmad Evans for collecting termites and the LSU AgCenter and LDAF for providing research funds.

AGGRESSIVE INTERACTIONS BETWEEN FORMOSAN SUBTERRANEAN TERMITE COLONIES FROM NEW ORLEANS, LOUISIANA

Mary L. Cornelius and Weste L. A. Osbrink
USDA-ARS, Southern Regional Research Center, New Orleans, LA

Aggressive behavior among colonies of the Formosan subterranean termite, *Coptotermes formosanus* Shiraki, is highly variable. Although many studies have explored possible cues involved in kin recognition by subterranean termites, the reasons for the high levels of variability in intercolonial aggression exhibited by Formosan subterranean termites remain unknown. This study examined the effect of diet, experimental design, and length of time in the laboratory on intercolonial aggression among *C. formosanus* colonies by pairing groups of termites from different colonies (intercolony pairs) in different bioassays. For all bioassays, intercolony pairs were tested immediately after field collection and then retested after spending different lengths of time in the laboratory.

For tests examining the effect of laboratory diet on intercolony interactions, termites were collected from four different colonies. One group of termites from each colony was kept on spruce and another group of termites from each colony was kept on red oak for 60 days. Tests were conducted using four intercolony pairs with 10 workers from each colony for the following diet combinations: spruce/spruce, red oak/red oak, colony x on spruce/colony y on red oak, colony x on red oak/colony y on spruce. Intracolony controls were conducted for the following diet combinations of each colony: spruce (20 workers), red oak (20 workers), and spruce (10 workers)/red oak (10 workers). In 24-hour Petri dish tests, results were confounded by the loss of aggressive behavior in intercolony pairs tested after being kept in the laboratory for 60 d. When the experiment was repeated and agonism tests were conducted using a 48-hour vial test where termites from the two colonies needed to tunnel through a sand-filled tube before encountering each other, relatively high levels of agonism were observed in two intercolony pairs after termites were kept in the laboratory for 60 d. However, there was no correlation between the level of aggressive behavior and the laboratory diet of the termites.

For tests examining the effect of experimental design and length of time in the laboratory on intercolonial interactions, termites were collected from six different colonies and three intercolony pairs were used. Tests were first conducted on the day of field collection, then intercolony pairs were retested every 7 d. Y-tube tests were designed to better simulate the field situation where termites encounter each other within their tunneling system and by creating an additional site with a food source that could only be reached by the construction of tunnels from the release sites of the two colonies. Aggressive behavior disappeared more rapidly in Petri dish tests than in sand-filled y-tube tests in two of the three intercolony pairs, and simultaneously in the third intercolony pair.

Many studies have examined aggressive interactions among subterranean termites in the laboratory. Aggression tests using small, isolated groups of foragers do not adequately reflect colony behavior in the field, regardless of bioassay design. The rapid decline of aggression among some colony pairs kept in the laboratory and tested in small groups is a confounding factor that makes it extremely difficult to identify cues used in kin recognition under laboratory conditions. However, changes in aggressive behavior by individuals from the same field collection kept under different laboratory conditions can provide information on cues that induce aggressive responses by subterranean termites towards non-nestmates.

OVERCOMING OBSTACLES TO SUCCESSFUL AREA-WIDE CONTROL OF FORMOSAN SUBTERRANEAN TERMITES IN NEW ORLEANS' FRENCH QUARTER

Frank S. Guillot[1], Dennis R. Ring[2], and Alan R. Lax[1]
[1]USDA-ARS, Southern Regional Research Center, New Orleans, LA
[2]Department of Entomology, Louisiana State University Agricultural Center, Baton Rouge, LA

Conventional strategies for subterranean termite control have failed to prevent the spread and increase of the Formosan subterranean termite (FST), which was introduced to the U.S. immediately after WWII. Nearly 50 years later, the FST population has grown enormously and the FST has become the dominant structural pest in areas such as New Orleans where it was introduced. An area-wide strategy that achieves population management and reduction was suggested as an alternative to structural protection for control of FST in New Orleans' French Quarter. Factors associated with the French Quarter neighborhoods, but not necessarily unique to the area, slowed progress after initial signs of termite population reduction. A revision of the original area-wide strategy was proposed to overcome the problems and achieve further reduction. These revised efforts have produced a 50 to 75% reduction of alates depending upon length of time an area has been under intense management and 98% reduction of termite activity in the French Market area and the adjacent railroad and levee.

NEW APPROACH TO AREA-WIDE MANAGEMENT OF THE FORMOSAN SUBTERRANEAN TERMITE (*COPTOTERMES FORMOSANUS*) IN LOUISIANA

Ken S. Brown[1], Claudia Riegel[1], Frank S. Guillot[2], and M. K. Carroll[1]
[1]New Orleans Mosquito and Termite Control Board, New Orleans, LA
[2]USDA-ARS, Southern Regional Research Center, New Orleans, LA

The Formosan subterranean termite (*Coptotermes formosanus*) is an economically important pest species that was accidentally introduced into multiple U. S. port cities in the mid 1940's. Since these introductions, the distribution of *C. formosanus* has increased markedly in the southern United States. Unwitting transport of infested building materials, landscape timbers, and other wooden items has often been implicated as the primary cause of this increasing distribution. In areas where it is established, *C. formosanus* is capable of supplanting native subterranean termites as the primary structural pest species. This is the case in New Orleans, the site of a federally mandated control effort initiated in 1998 under the direction of the USDA-ARS. Current research has shown that one factor that contributes to the challenges associated with area-wide management efforts in New Orleans' historic French Quarter is the colony density in this area and the ability of subsequent colonies to readily utilize territories vacated by established populations. Effective area-wide management of more recently introduced populations of *C. formosanus* has been seen in other areas of the United States. Recent surveys of the state of Louisiana have identified multiple seemingly isolated populations of *C. formosanus* in locations that previously had not had confirmed reports. Utilizing area-wide management strategies in these locations may prove to be an effective method in limiting the increasing distribution of this destructive species in the state of Louisiana.

INSPECTIONS OF TREES AND PROPERTIES IN MANAGING THE FORMOSAN SUBTERRANEAN TERMITE IN THE FRENCH QUARTER PROGRAM, NEW ORLEANS, LOUISIANA

Dennis Ring[1], Alan Morgan[1], Frank Guillot[2], Alan Lax[2], Charles McCown[1], and Claudia Reigel[3]
[1]Department of Entomology, Louisiana State University Agricultural Center, Baton Rouge, LA
[2]USDA-ARS, Southern Regional Research Center, New Orleans, LA
[3]New Orleans Mosquito and Termite Control Board, New Orleans, LA

The Formosan subterranean termite, *Coptotermes formosanus* Shiraki, causes serious damage to structures in the French Quarter, New Orleans, LA. Densities of this termite and damage to structures in the French Quarter are being reduced through area-wide integrated pest management--The French Quarter Program is a cooperative effort between the Louisiana State University Agricultural Center, USDA-ARS, and the New Orleans Mosquito and Termite Control Board.

Formosan subterranean termites may infest trees and woody plants, which then serve as reservoirs of termites to infest structures. Aerial photography and visual inspection of properties in the Program were used to locate woody plants in 56 contiguous blocks (bordered by Bienville, Dauphine, and Esplanade Streets and the Mississippi River front) of approximately 96 blocks total in the French Quarter. They were then inspected visually and with an acoustical probe for evidence of Formosan subterranean termites beginning in spring 2004 and continuing through spring 2008.

During this 4-year period, a total of 2,714 trees and 1,340 properties were inspected, and Formosan subterranean termites were found infesting 41 trees (~1.5%) and 21 properties (<2.0%). Infested trees were treated with baits (15 properties), liquid termiticides (4 properties), or both (2 properties). Infested trees were inspected annually and retreated when termites were found. At the last inspection (April 2008) termites were not found in treated trees. Low percentages of properties with infested trees and low percentages of infested trees were observed. This suggests that trees are probably not a major source of termites infesting properties in these 56 blocks of the French Quarter. However, alates in large numbers may emerge from infested trees resulting in the establishment of new colonies. Inspections, re-inspections, and treatment of infested trees are continuing in an effort to further reduce the densities of termites in the Program area.

Inspections of properties in the Program area of the French Quarter have resulted in the location of termites in structures and subsequent treatment of the structure. Sometimes structures have been inspected and treated several times. Inspections of structures are very important in further reducing the number of Formosan subterranean termites in the Program area. Such inspections are continuing on an ongoing basis.

SYMPOSIUM

BLOOD-SUCKING HITCHHIKERS—THE RETURN OF FLEAS AND TICKS

20 May 2008

Organizers:
Deanna Branscome (Syngenta Home Care) and Phil Koehler (University of Florida)

THE DIVERSITY OF URBAN FLEAS (SIPHONAPTERA) AND THEIR NATURAL HISTORY IN THE SOUTHEASTERN UNITED STATES

William H. Kern, Jr.
Entomology & Nematology Department, Ft. Lauderdale Research and Education Center,
University of Florida, Davie, FL

The diversity of fleas encountered by pest management professionals is very limited. Most fleas are host specific to the species, genus, or family level, depending on the species of flea. The fleas commonly infesting companion animals (Tables 1 and 2) are species with unusually broad host ranges [*Ctenocephalides felis, Echidnophaga gallinacea,* and *Pulex irritans* (North) or *Pulex simulans* (South)]. Rodent fleas (Table 3) can be a nuisance following host elimination during rodent control efforts. These include *Xenopsylla cheopis, Nosopsyllus fasciatus, Leptopsylla segnis*, and to a lesser extent *Orchopeas howardii.* Accidental infestations of companion animals by fleas from rabbits and native rodents are generally self-limited and these fleas do not perpetuate infestations on dogs and cats. There is concern about disease transmission from wildlife to companion animals.

Fleas regularly found on companion animals and inside structures in <u>urban and suburban</u> locations include:

Family Pulicidae
Ctenocephalides canis – Dog flea. Uncommon on domestic dogs unless wild canids are sympatric.
Ctenocephalides felis – Cat flea. Broad host range.
Echidnophaga gallinacea – Sticktight flea. Broad host range – birds and mammals.
Pulex irritans – Human flea. Broad host range.
Pulex simulans – Southern human flea. Broad host range.
Xenopsylla cheopis – Oriental rat flea. On *Rattus* and predators of rats.
Cediopsylla simplex – *Sylvilagus* rabbit flea On *Sylvilagus* sp.

Family Ceratophyllidae

Nosopsyllus fasciatus – Northern rat flea. On *Rattus*, especially Norway rats.

Ceratophyllus gallinae – European chicken flea.

Orchopeas howardii – Squirrel flea. On all arboreal sciurids.

Family Leptopsyllidae

Odontopsyllus multispinosus – Cottontail rabbit flea. A widespread flea on cottontail rabbits, *Sylvilagus* sp., but usually less abundant than *Cediopsylla simplex.*

Leptopsylla segnis – the European house mouse flea. On *Mus musculus* and predators.

Family Rhopalopsyllidae

Polygenis gwyni – Cotton rat flea. Very broad host range – anything found in the same habitat as *Sigmodon hispidus* or that eats hispid cotton rats (rodents such as *Peromyscus*, *Neotoma, Rattus, Oryzomys,* and *Neofiber;* predators such as opossum, spotted skunk, long-tailed weasel, dogs, and cats).

Table 1. Fleas recovered from domestic dogs in southeastern Georgia, USA, 1996-2004. From Durden et al. (2005).

Flea species	No. collected (♂,♀)	% of total
Ctenocephalides felis	1537 (389, 1148)	61.0
Ctenocephalides canis	535 (250, 285)	21.2
Pulex simulans	319 (106, 213)	12.7
Echidnophaga gallinacea	92 (3, 89)	3.7
Cediopsylla simplex	25 (10, 15)	1.0
Odontopsyllus multispinosus	6 (4, 2)	0.2
Orchopeas howardi	3 (1, 2)	0.1
Polygenis gwyni	1 (1♂)	<0.1
Total	2518 (764, 1754)	

Table 2. Fleas on feral cats from north central Florida during the summer. From Akucewich et al. (2002).

Flea species	Cats infested	Fleas per cat
Ctenocephalides felis	185/200 92.5%	13.6 ± 16.4
Pulex simulans	9/200 4.5%	1 ± 0.50
Echinophaga gallinacea	11/200 5.5%	14.8 ± 9.63

Table 3. Flea species collected from commensal rats (*Rattus* spp.) in Florida. From Forrester (1992).

Flea species from rats in Florida	*Rattus rattus* Roof Rat	*Rattus norvegicus* Norway Rat
Ctenocephalides canis	X	X
Ctenocephalides felis	XX	X
Echidnophaga gallinacea	XX	XX
Xenopsylla cheopis	XX	XX
Nosopsyllus fasciatus	X	XX
Orchopeas howardii	X	
Leptopsyllus segnis	XX	XX
Polygenis gwyni	XX	XX

XX multiple counties or records X single record reported

References

Akucewich, L. H., K. Philman, A. Clark, J. Gillespie, G. Kunkle, C. F. Nicklin, and E. C. Greiner. 2002. Prevalence of ectoparasites in a population of feral cats from north central Florida during the summer. Veterinary Parasitology 109: 129-139.

Durden , L. A., T. N. Judy , J. E. Martin, and L. S. Spedding. 2005. Fleas parasitizing domestic dogs in Georgia, USA: Species composition and seasonal abundance. Veterinary Parasitology 130: 157-162.

Forrester, D. J. 1992. Parasites and Diseases of Wild Mammals in Florida. University Press of Florida.

HOW FLEA BIOLOGY AND BEHAVIOR IMPACT CONTROL STRATEGIES

Nancy C. Hinkle
Department of Entomology, University of Georgia, Athens, GA

An adult flea spends its entire life on the dog or cat. As eggs are laid, they fall off the host animal and collect in the environment (carpet or dirt). Flea larvae emerge from eggs within a couple of days and crawl around, eating the adults' feces. In about two weeks, the larva completes its development and spins a cocoon within which it transforms into an adult. Once this metamorphosis has taken place, the adult flea remains within the cocoon until it is stimulated to emerge. The pharate flea can remain in its cocoon for months, allowing a flea infestation to persist for long periods without an animal being present. Cues that signal the presence of a nearby host include movement, heat, and carbon dioxide (exhaled by all mammals). Upon detecting one of these stimuli, the flea bursts from the cocoon and hops toward the host. It repeatedly flings itself against the host until its claws catch. To avoid being groomed off or knocked loose, the flea burrows into the host's hair coat. Adult fleas must suck blood once an hour, so they seldom leave the host once it is acquired. On the host, fleas live for two or three weeks.

Fleas can live on wild animals such as opossums, raccoons, foxes, skunks, etc., so it is important to discourage wild animals from visiting backyards and sharing their fleas. Pet food should not be left outside at night, and garbage cans should be sealed to prevent attracting wildlife. Crawl space openings should be screened and wild animals should be prevented from denning under the house, in the attic, or in outbuildings.

Flea eggs, larvae, and pupae are dispersed in the environment, making fleas very difficult to control. One efficient flea control method is to use the host (dog or cat) as the 'bait'; various products can be used to treat the host and thus kill adult fleas as they seek a blood meal on the animal. Pets should be treated early during the spring, before fleas become a problem, to prevent large populations becoming established in the environment. Over-the-counter products, while less expensive, do not contain the same ingredients as those obtained through veterinarians, and they also may be more toxic. Because pesticides can sicken or kill pets and people if used incorrectly, it is important that label directions be followed scrupulously.

Some insecticides may be given orally to the host so that the active ingredient passes into its bloodstream and is picked up as the flea feeds. Orally administered products include neonicotinoids (such as nitenpyram) and spinosyns (e.g., spinosad).

Other insecticides may be topically applied to the host so that the flea acquires the toxicant via its cuticle. Topical products generally are maintained in the host's dermal lipids where they are available for cuticular absorption by fleas. Host-targeted topically applied ectoparasiticides include pyrethrins, pyrethroids (e.g., permethrin), neonicotinoids (e.g., imidacloprid, dinotefuran), phenylpyrazoles (e.g., fipronil), macrocyclic lactones (e.g., selamectin), and semicarbazones (e.g., metaflumizone).

Although insect growth regulators (IGRs) and chitin synthesis inhibitors do not kill adult fleas, they can act as ovicides and larvicides, preventing flea eggs from hatching and larvae from successfully molting. Lufenuron is a chitin synthesis inhibitor that is administered orally either as a pill for dogs, or as a liquid added to food or an injectable formulation for cats. Pyriproxyfen and methoprene are juvenile hormone analogs that can be applied topically to the host.

Some products (e.g., those containing permethrin) are toxic to felines and not labeled for use on cats; they also are not labeled for use on young puppies. Organophosphate and carbamate insecticides were commonly used for ectoparasite control in the past, but their use now is limited to specific formulations (such as flea collars). While application methods such as shampoos, dips, mousses, dusts, etc. were used in the past, low-volume topical application of lipophilic formulations has replaced these modalities.

Environmental flea control efforts should be focused on areas where pets spend the most time, especially where they sleep, as these locations can readily support larval development. Vacuuming will simultaneously remove larvae and the material upon which they feed. Steam-cleaning is effective against all flea developmental stages, as the steam even penetrates the cocoon to kill pupae and pharate adults. Most of the products registered for indoor environmental flea control are IGRs or pyrethroids, although there are some botanical and organophosphate products. Insecticide applications to the household will have delayed effects because the chemical does not penetrate to larval and pupal locations at the carpet base. Products registered for household application are limited, and there are no adulticides registered for general broadcast treatments indoors. Spot treatments must be targeted for maximal effectiveness, illustrating why knowledge of flea biology and behavior is critical. IGR applications following steam cleaning will prevent subsequent re-infestation.

Outdoor flea control can be particularly challenging, as wild and feral animals may continually re-infest premises. Flea larvae cannot survive the heat and drying conditions of full sun exposure, so control efforts should be directed to shaded areas of host activity. Typically this includes under shrubbery, against foundations, and in crawl spaces or areas under porches or decks. Products ideally should have sustained residual efficacy and photostability.

Because different flea species have idiosyncratic host preferences, biology, and behaviors, proper identification of the flea species is essential to ensure appropriate control strategies. The better we understand the pest, the more effective we can be in designing methods to suppress it.

ECOLOGY AND MANAGEMENT OF TICKS IN THE URBAN ENVIRONMENT

Pete D. Teel
Department of Entomology, Texas A&M University, College Station, TX

Ticks threaten the health and well-being of both humans and companion animals in urban environments through their blood feeding and the risk of tick-borne diseases. Ticks can enter urban environments and be sustained by a variety of means. Humans and their companion animals are exposed to ticks through occupational activities (ranching, utilities work, construction site work, etc.) and recreational activities (hunting, fishing, hiking, trail riding, etc.) and may bring ticks into their residences. Ticks may also enter these environments and be sustained by urban wildlife (opossum, raccoons, coyotes, rodents, feral cats, and dogs).

Ticks commonly found on domestic dogs and cats in southern urban residences include the brown dog tick, *Rhipicephalus sanguineus;* the American dog tick, *Dermacentor variabilis;* the lone star tick, *Amblyomma americanum*; the Gulf Coast tick, *A. maculatum*; and the deer tick, *Ixodes scapularis*. All of these ticks need a blood meal at the larval, nymph, and adult stage in order to complete their life cycle, and all but the brown dog tick need from 1-2 years to complete a generation.

The brown dog tick is the most ubiquitous in distribution in the U.S. It is the most frequently encountered tick in urban residential areas, and it is often the most difficult tick to control. The international scope of this tick and its host range are discussed in this presentation.

In North America, dogs are the principle host for all stages of the brown dog tick; however the opossum, the house mouse, and the hispid cotton rat have been found infested by immature stages of this tick. The host range of the brown dog tick in the U.S. is not well investigated. Humans are attacked, but not as readily as by several other tick species. Large numbers of brown dog ticks can result where penned dogs are readily available (residential areas, kennels, etc.) to host-seeking ticks in each developmental stage.

Under optimal temperatures and host availability, the brown dog tick can produce a generation in 60-70 days. Most of the life cycle is spent off-host in habitats for egg laying, incubation, molting, and host-seeking. Such habitats are located wherever dogs frequent, both outdoors and indoors, and include vegetation and/or leaf-litter in yards, doghouse bedding, and other resting areas such as under decks or other outdoor structures and on indoor carpets, rugs, furniture, and draperies. This tick likes to climb and may be found on walls, inside and outside, as high as the ceiling or eaves. This tick also makes use of all kinds of cracks and crevices.

Tick habitat and behavior, as well as dog behavior, should be considered when treating both indoor and outdoor premises. Gaps in treatment will provide sources for ticks that become chronic problems. There are numerous products available over-the-counter and through veterinarians for on-animal treatment. On-animal and premise treatments should be coordinated so both the on-host tick blood feeding and off-host tick populations are addressed. This is an opportunity for the owner, veterinarian, and pest control professional to work together to get optimal tick control. Discussions with homeowners and kennel owners complaining of persistent tick problems often reveal a history of repeated premise and animal treatments across the array of available pesticide classes and formulations without a successful suppression of brown dog ticks. Further discussion can reveal gaps or complications that impede best management of ticks. For example, premise treatments may miss cavities under doghouses or doghouse bedding as important off-host habitats. Infested bedding in these cases can be bagged in black plastic to kill ticks and then be disposed; new bedding material can similarly be replaced at 2-week intervals to reduce tick treatment escape.

In some cases, treatments for other pests may interfere with, or complicate, treatments for ticks. For example, preventative treatments for mosquitoes offered by automatic spray-mist applicator systems in kennels infested with brown dog ticks may exacerbate development of insecticide tolerance or resistance against ticks. Understanding tick biology and ecology is the first key to successful management of ticks in urban environments.

SUBMITTED PAPERS

PUBLIC HEALTH PESTS

20 May 2008

BED BUG MANAGEMENT: PRACTICAL EXPERIENCES IN THE FIELD AND A RESPONSE TO INSECTICIDE RESISTANCE

Byron L. Reid and Joe Barile
Bayer Environmental Science, Research Triangle Park, NC

Laboratory research on insecticide susceptibility and resistance mechanisms is critical to the long-term sustainability of management programs for bed bugs. However, baseline studies on performance of existing pest management programs are all but non-existent in this "modern era" of bed bug management. Such baseline studies of insecticide susceptibility <u>in the field</u> are required to provide a scientifically valid basis for management recommendations, particularly with regard to theoretical resistance issues. In other words, the science must connect with the practical realities faced by practitioners in the field. In recent years, a series of control programs were completed in the United States in cooperation with universities and the pest management industry. These programs focused on the pyrethroid class of insecticides, which are the predominant chemistries registered for bed bug control in the U.S.

The first series of trials were completed in 2005 to 2007 and examined the effectiveness of the pyrethroid, deltamethrin (Suspend® SC [0.06% deltamethrin]), and select other pyrethroids. The bulk of the treatment used liquid spray dilutions of deltamethrin, but dust formulations of deltamethrin and other pyrethroids were occasionally used to supplement the liquid sprays. This field research, carried out in three cities (Cincinnati, OH; Indianapolis, IN; and Arlington, VA), established that pyrethroid products can be used to effectively gain control of bed bug infestations. However, the treatment programs required to achieve effective control (e.g., ≥90% reduction in bed bug counts compared to pre-treatment counts) were very intensive. On average, it was necessary to follow one initial treatment service with two additional treatment services to gain the 50th percentile of control in these trials; to achieve 90th percentile control required two further services, for a total of five treatment services. These treatment services were spaced about 2 weeks apart, so it required 2 months of intensive service to gain control of bed bug infestations. The cumulative volume of pesticide applied in the treatment regimes totaled ca. 5 liters of insecticide dilution (sprays) and ca. 100 grams of dust formulation; however, the initial service was responsible for more than half of this quantity, with progressively smaller applications required in each successive treatment. Most practitioners have observed, and we concur, that this level of investment in bed bug management programs is not sustainable, nor is it in the long-term best interests of either the pest management industry or their clientele. Improvements over the existing programs are required.

In discussions with innovative practitioners, we learned of an emerging strategy that was meeting some success in improving the efficiencies of bed bug treatment strategies. Therefore, a second series of field trials was completed in 2007, wherein we examined the effects of a tank mixture of deltamethrin with a piperonyl butoxide synergized (10:1) pyrethrins formulation. These tests sought to quantify the improved outcomes in management programs using this tank-mix strategy. Trials were established in two cities (Fairfield, CT; New York, NY) in the northeastern U.S. to compare the use of deltamethrin sprays alone with the deltamethrin + piperonyl butoxide + pyrethrins spray (Suspend® + Kicker®) treatment. We found that the efficiency of the treatment program was greatly enhanced by use of this tank-mix strategy, as initial knockdown of the bed bug population was increased and effective control (e.g., >90% reduction in bed bug counts compared to pre-treatment counts) of the infestation was achieved in a shorter time with fewer re-services. In fact, 1 week after the initial application of Suspend® + Kicker®, a ~95% reduction in bed bug counts was observed. The number of treatments was cut in half, which is a great benefit to both the practitioners and the residents alike as the bed bug infestation could be controlled with less cost and fewer insecticide applications. Practitioners reported “seeing” more evidence of efficacy during treatment (perhaps attributable to the flushing actions of the pyrethrins?) and, more significantly, residents reported that biting episodes ceased more quickly following use of the deltamethrin + piperonyl butoxide + pyrethrins tank mix. Clearly these results suggest that the synergist increased the lethality of the treatment to bed bugs, however it cannot be known if this was due to overcoming a resistance to insecticides as no bed bugs were collected for resistance characterization in laboratory studies.

Based on these experiences in the field, Bayer Environmental Science now recommends tank-mixtures of Kicker® with Suspend® for every bed bug job, but most especially when difficult control situations are encountered. While this tank-mix strategy may not be a long-term solution, for today (at least) this is an effective response to increase the ability of the industry and society to confront the continued rise in the incidence of bed bug infestations, both nationally and around the world. For a truly sustainable solution, basic research into resistance mechanisms in the common bed bug is required to compliment these initial, modest efforts.

ECLOSION OF BED BUG (*CIMEX LECTULARIUS*) EGGS AFTER EXPOSURE TO VARIOUS COMPOUNDS

Eric J. Snell, Todd Smith, and Wally Sexton
Snell Scientifics LLC, Meansville, GA

Understanding the ovicidal effects of pesticides on bed bug (*Cimex lectularius*) eggs is critical to the success of any bed bug control program. A variety of pesticides, including Suspend® SC, Kicker® EC, and a combination of both, were evaluated for their effects on bed bug eggs using two methods: 1) applied directly to eggs and 2) applied as a residual, with eggs exposed only to the residue. The products were evaluated for the ability to prevent eggs from hatching as well as for effects on the survival of newly hatched first instar nymphs. The pesticides were tested individually as well as in combination in order to evaluate potential synergistic effects.

The results of these tests illustrated that Suspend® SC and Kicker® EC, when applied individually, prevented 95% and 92% of the eggs from hatching. Of the few treated bed bug eggs that did hatch, none survived 24 hours after hatching. The combination of Suspend® + Kicker® prevented 100% of the eggs from hatching.

When bed bug eggs were placed on treated unpainted wood surfaces, 40-70% hatched but no more than 3% of the first instar nymphs survived any of the three treatments (Suspend® SC, Kicker® EC, and Suspend® SC + Kicker® EC). However, on treated mattress ticking, there were greater differences in survival of first instar nymphs among the three treatments: 85% survival occurred with Suspend® SC, 25% survival occurred with Kicker® EC, but only 5% survival of first instars resulted when Suspend® SC and Kicker® EC were mixed together and applied to mattress ticking. The results were the same or better when the residuals were tested 30 days after application to both unpainted wood and mattress ticking.

EVALUATION OF EFFECT OF TRUCK CARGO CONTAINER CONFIGURATION, SEALING METHOD, AND DURATION OF FAN OPERATION ON CONFINEMENT OF VIKANE® GAS FUMIGANT (SULFURYL FLUORIDE)

Ellen Thoms[1] and Rudolf Scheffrahn[2]
[1]Dow AgroSciences LLC, Gainesville, FL
[2]University of Florida, Ft. Lauderdale Research and Education Center, Ft. Lauderdale, FL

Abstract

Moving trucks may serve as convenient, minimum labor portable fumigation chambers, especially for bed bug-infested goods. The effect of container configuration, tape-and-seal method, and duration of fan operation on half loss time (HLT) of Vikane® gas fumigant (sulfuryl fluoride) was evaluated. Two types of truck cargo container were evaluated: a 7.9 m long, 55.2 m^3 cargo container separate from the cab and a 4.6 m long, 22.4 m^3 cargo container attached to the cab. Two trucks of each type were evaluated. The HLTs for the 55.2 m^3 containers (mean = 18.1 h) were significantly better than those for the 22.4 m^3 containers (mean = 5.4 h). The 55.2 m^3 containers had good fumigant confinement compared to the 22.4 m^3 containers due their larger volume, detached cab, and new construction. Applying polyethylene to seal the rear rolling door of the 55.2 m^3 container or the cab of the 22.4 m^3 container did not improve the HLT. Taping the bottom of the hollow frame around the rear rolling door improved the HLT by 3-fold for the 22.4 m^3 container. Using the same sealing techniques on vehicles of the same model and condition resulted in different HLTs. Therefore, it is necessary to monitor tape-and-seal fumigations to determine actual HLT and dosage accumulation. The mean HLTs were not significantly different for trucks with fans off: fans on after fumigant equilibrium. Nonetheless, 6 of the 8 containers had better fumigant confinement (higher HLTs) when the fan was turned off compared to when it was on.

Introduction

Bed bugs, family Cimicidae, include three species that are known to feed on humans. The common bed bug, *Cimex lectularius*, prefers humans as its primary host. The widespread use of chlorinated hydrocarbons (i.e., DDT, lindane, chlordane) in the 1950s and 1960s effectively controlled bed bug infestations, subsequently making this pest very uncommon in the U.S. (Pinto et al. 2007). In recent years, however, pest management professionals throughout the U.S. have reported an increase in bed bug infestations in buildings, particularly in hotels, dormitories, youth hostels, apartments, homeless shelters, and other multi-unit dwelling facilities. Reduced interior application of broad-spectrum insecticides, bed bug resistance to commonly-used pyrethroid insecticides (Romero et al. 2007), and increased international travel have been implicated for the increased occurrence of bed bugs.

Vikane® gas fumigant (99.8% sulfuryl fluoride [SF], Dow AgroSciences, Indianapolis, IN) is highly effective at eradicating all life stages of bed bugs, including eggs, when applied at 3-fold the dosage for drywood termites. Fumigation with Vikane® of whole structures (Thoms 2003) and containerized household furnishings (Walker et al. 2008) is being implemented by pest control managers for control of bed bugs in heavily infested dwellings. Walker et al. (2008) fumigated a truck enveloped in polyethylene and measured a fumigant half-loss time (HLT) of 65 h. Tarping a truck can be material and labor intensive; however, there is currently no published information available on the HLTs of Vikane® from trucks sealed using alternative methods.

The purpose of the trials herein was to evaluate the effect of the following variables on fumigant confinement in truck containers; container configuration, tape-and-seal method, and duration of fan operation.

Materials and Methods

Truck Containers: Two types of trucks were evaluated: a 7.9 m (26 ft) long, 55.2 m^3 (1,950 ft^3) cargo container separate from the cab and a 4.6 m (15 ft) long, 22.4 m^3 (790 ft^3) cargo container attached to the cab. Two trucks of each type were evaluated.

Environmental Monitoring: One WatchDog® data logger (Spectrum Technologies, Plainfield, IL) was placed in each truck cargo container to record temperature and % RH at 30 min intervals. A manual wind gauge (Dwyer Instruments, Michigan City, IN) was used to measure maximum wind speed intermittently each day.

Sealing Methods: Use of 51 mm (2 inch) wide blue painter's tape (3M, St. Paul, MN) alone or in combination with 4-mil polyethylene sheeting was evaluated. Blue tape was used to prevent damage to vehicle paint. Masking tape was used to reinforce attachment of blue tape to polyethylene when required.

For the first fumigation of 55.2 m^3 and 22.4 m^3 containers, the rear rolling door of each container (Figure 1) and side door of the 55.2 m^3 container were sealed with blue tape. In addition, gaps in the ceiling of cab attached to the 22.4 m^3 container were sealed with blue tape.

For the second fumigation, different sealing methods were evaluated for each truck as follows:

- 55.2 m^3 container A (55-A): The container was fumigated with no sealing.
- 55.2 m^3 container B (55-B): Polyethylene sheeting was taped to the rear rolling door (Figure 2) and the blue tape remained on the side door from the first fumigation.
- 22.4 m^3 container A (22-A): Blue tape remained on the rear rolling door and polyethylene was taped (blue tape reinforced with masking tape) to separate the cab from leaky connections to the container.
- 22.4 m^3 container B (22-B): The container and cab were prepared the same as for Truck 22-A, plus blue tape was used to seal the opening in the base of the hollow frame around rear rolling door.

Figure 1. Rear rolling door of truck container sealed with blue tape.

Figure 2. Polyethylene sheeting was taped to the rear rolling door of truck container.

<u>Duration of Fan Operation:</u> One 2.0 amp fan (King of Fans, Inc. or All Things Industrial, Inc.) was operated for 15 min during fumigant introduction. The one exception was Truck 55-A during the 2nd fumigation on 11/28/07 in which fumigant was introduced without the fan operating to determine how rapidly SF distributed. Ten min after introduction, the fan was turned on for 15 min as in the other fumigations.

Fumigant HLT during the 6 h exposure was determined with the fan off for 3 h, then with the fan turned on again for 3 h. Fans were turned off and on remotely by unplugging them from extension cords.

<u>Fumigant Monitoring:</u> Two Fumiscopes® (models 5.0 and D with an internal drying tube, Key Chemical and Equipment Co., Clearwater, FL) were used to measure SF concentrations during the fumigant exposure period. The calibration of each Fumiscope® was checked daily using SF diluted in air to a known concentration of 86 g/m^3 (oz/1000 ft^3). Calibration gas in the compressed air cylinder was prepared and analyzed by Scott-Marrin, Riverside, CA.

Two 1.3 cm (0.5 inch) OD monitoring hoses were installed in each container, one designated “low” near the floor and one designated “high” near the ceiling. One additional monitoring hose designated “middle” was placed mid-level in 55.2 m^3 container for Truck 55-A during the 2nd fumigation on 11/28/07. Measurements were taken from the middle monitoring hose during the 25 min following fumigant introduction to determine the effect of introducing fumigant without the fan operating. Blue tape was loosely crumpled into a spongy ball to cushion monitoring and introduction hoses so as to prevent them from being crushed by the rear rolling doors of the containers.

Leak testing around each container and in each cab was conducted using the SF-ExplorIR® (Spectros Instruments, Hopedale, MA). The location and amount of SF leaking was recorded. A maximum of 100 ppm SF can be measured using the SF-ExplorIR®, which issues an error code for concentrations >100 ppm.

Fumigant Introduction: The target dose of SF was 1.4 kg (3 pounds) per 55.2 m^3 container and 0.5 kg (1.2 pounds) per 22.4 m^3 container, resulting in a theoretical concentration of 24 g/m^3 (oz/100 ft^3) per container. SF was introduced remotely through 30.5 m (100 ft) of 3 mm (1/8 inch) ID introduction hose attached to a stand and facing into the air stream of the 2.0 amp fan. SF was weighed during introduction using a digital hanging scale (model C-11, Ohaus, Pine Brook, NJ). Prior to sealing the rear rolling door, approximately 7 ml (0.25 oz) of chloropicrin was poured into a shallow pan (Cardinal Professional Products, Woodland, CA) placed in front of the introduction fan.

HLT Calculations: The actual HLT was calculated by obtaining the mean fumigant concentration for each time interval and using a HLT calculator (T. Wontner-Smith, Central Science Laboratory, England).

Safety Procedures: All safety procedures mandated by the product label for Vikane® gas fumigant and Florida state regulations were followed, including use of personal protective equipment, posting the fumigated vehicles, locking the containers with padlocks owned by the fumigator, and clearance testing following aeration.

Results and Discussion

Environmental Monitoring: The wind speed gusted to 9.7 km/h (6 mph) on each test day. The temperature and % relative humidity for each truck container during the 6-h exposure period are documented in Table 1. During the fumigation trials, the maximum temperatures and % RH were relatively consistent and no rainfall occurred. These environmental parameters provided equivalent conditions for comparing the variables of container configuration, sealing technique, and fan operation.

Table 1. Temperature (°C) and % relative humidity (RH) in each truck container during the 6-h fumigation exposure period.

Date	Truck[a]	Mean °C	Max-Min °C	Mean ± SD % RH	Max-Min % RH
11/27/2007	55-A	32.4	34.5 - 29.9	60.0 ± 1.7	62.6 - 57.2
11/27/2007	55-B	32.8	35.8 - 29.6	61.0 ± 1.8	63.3 - 58.1
11/28/2007	55-A	32.0	35.3 - 26.8	61.2 ± 5.5	70.5 - 54.5
11/28/2007	55-B	32.3	35.3 - 26.0	64.3 ± 3.4	72.2 - 59.4
11/29/2007	22-A	35.4	37.5 - 30.8	54.9 ± 1.1	57.5 - 53.1
11/29/2007	22-B	35.7	37.5 - 32.0	56.2 ± 1.2	58.3 - 54.0
11/30/2007	22-A	29.1	35.8 - 21.3	60.1 ± 10.3	74.3 - 48.6
11/30/2007	22-B	29.2	36.2 - 21.7	60.3 ± 8.3	70.9 - 51.4

[a] Trucks 55-A and 55-B had detached cab; trucks 22-A and 22-B had attached cab.

Container Configuration: The HLTs for the 55.2 m^3 containers (mean = 18.1 h) were significantly better (Welch's t-test[logHLT]; p = 0.0003, 9.383 df, t = -.9744) than those for the 22.4 m^3 containers (mean = 5.4 h, Table 2). The container for Truck 55-A with no sealing had a HLT (3.5 h) equivalent to the 2.1-4.3 h HLT of the 22.4 m^3 containers with tape sealing.

The 55.2 m^3 containers demonstrated good fumigant confinement due to their large size, detached cab, and near pristine condition. Fumigant leakage from the 55.2 m^3 containers was generally minimal, ≤20 ppm SF. No SF was detected leaking from exterior metal moldings on the containers or inside the cabs during fumigation. Only Truck 55-A on 11/27/07 had leakage of 80-100 ppm SF at the base of the rear rolling door.

Table 2. Half loss times (HLTs) (hours) of Vikane® gas fumigant in trucks[a] based on container length, seal method, and fan operation.

Container	Truck	Seal Method	Fumigant half loss time (HLT)		
			Fan Off	Fan On	Mean
55.2 m^3	55-A	Tape doors	24.9	16.7	20
	55-B		24.9	38.8	30.4
22.4 m^3	22-A	Tape rear door & cab	3.5	1.5	2.1
	22-B		4.8	3.9	4.3
55.2 m^3	55-A	None	4.7	2.8	3.5
	55-B	Tape side door; poly rear door	16.5	20.5	18.3
22.4 m^3	22-A	Tape rear door & poly cab	5.7	1.4	2.3
	22-B	Tape rear door/frame & poly cab	16.6	10.6	13

[a] Trucks 55-A and 55-B had detached cab; trucks 22-A and 22-B had attached cab.

The 22.4 m^3 containers had poor fumigant confinement due to their small size, attached cab, and worn condition. From 73-100+ ppm SF was detected in the attached cabs of the 22.4 m^3 containers during fumigation, except in Truck 22-A during 11/29/07 when only 2 ppm SF was detected. Over 100 ppm SF was detected at the base of the hollow frames for the rear rolling doors and 2-7 ppm SF was detected leaking from exterior metal moldings of the containers during all fumigations.

Sealing Methods: Applying polyethylene to the rear rolling door of container for Truck 55-B did not improve fumigant confinement given that it reduced the HLT (Table 2). For the 22.4 m^3 containers, applying polyethylene to the cab did not markedly improve the HLT for Truck 22-A (from 2.1 h to 2.3 h), but taping the bottom of the hollow frame around the rear rolling door improved the HLT by 3-fold for Truck 22-B (from 4.3 h to 13 h). The value of sealing the bottom of the hollow rear rolling door frame for improving fumigant confinement was identified because we conducted leak testing after fumigant introduction.

Fan Operation: Introducing SF without a fan still resulted in rapid distribution of the fumigant. Immediately after introduction was completed, SF was measured in all three locations (low, medium, and high) in Truck 55-A on 11/28/07. Ten min after introduction was completed, SF concentrations were within 5 oz at the three monitoring locations without a fan operating. The total time that would have been required for the fumigant to reach equilibrium was not determined. Nonetheless, operating a fan during fumigant introduction is required by the label to avoid condensation or splattering of liquid fumigant.

The mean HLTs (12.7 h: 12.0 h) were not significantly different for trucks with fans off: fans on after fumigant equilibrium (Welch's t-test [logHLT], $p = 0.2355$, $df = 12.013$, $t = -0.7444$). Nonetheless, 6 of the 8 trials had better fumigant confinement (higher HLTs) when the fan was turned off compared to when it was on (Table 2).

Conclusions

The following conclusions made about conducting tape-and-seal fumigation of truck containers, based on fumigations conducted on a limited sample size of four trucks, are consistent with observations made by the authors during 20 years of measuring fumigant confinement in many types of structures.

1. Containers with attached cabs can lose fumigant more rapidly than containers with detached cabs.
2. Larger containers may have better fumigant confinement than smaller containers.
3. New containers may have better fumigant confinement than old containers.
4. Using the same sealing techniques on the same model and age vehicles can still result in different HLTs.
5. Using a leak detector, such as a TIF or ExplorIR®, can assist in identifying leaks for improved sealing and confinement.
6. Fans should be turned off after reaching equilibrium in containers. Leaving fans on can reduce HLT for small, leakier spaces.
7. It is necessary to monitor tape-and-seal fumigations to determine actual HLT and dosage accumulation.

References

Pinto, L. J., R. Cooper, and S. K. Kraft. 2007. Bed Bug Handbook. The Complete Guide to Bed Bugs and Their Control. Pinto and Associates, Mechanicsville, MD.

Romero, A., M. F. Potter, and K. F. Haynes. 2007. Insecticide-resistant bed bugs: Implications for the industry. Pest Control Technology 35(7): 42, 44, 46, 48, 50, 143.

Thoms, E. M. 2003. Vikane® Gas Fumigant for Eradication of Bed bugs, *Cimex lectularius*, Infesting a Single-Family Residence in Northeast Florida. Internal Report, Dow AgroSciences, 6 pp.

Walker, W., K. Glover, P. Koehler, E. Thoms, and E. Hobelmann. 2008. Fumigation, steam, dusting, and labor: A review of a successful formula for bed bug control developed by pest management professionals at the University of Florida. Pest Control Technology 36(1): 40, 42, 44-46, 48, 50.

BED BUG INSECTICIDE RESEARCH: WHAT HAVE WE LEARNED?

Alvaro Romero, Kenneth F. Haynes, and Michael F. Potter
Department of Entomology, University of Kentucky, Lexington, KY

Insecticides often are the first line of defense for control of urban pests, including bed bugs, *Cimex lectularius*. In a recent online survey among the pest management industry, 91% of responders reported having routinely applied insecticide sprays to control bed bugs (Potter 2008). Despite the common use of insecticides, little is known about their efficacy to control bed bug infestations. In a field study, Potter et al. (2006) found that some infestations were especially resilient, surviving direct spray applications with a widely-used pyrethroid insecticide. These considerations lend urgency to the need for up-to-date information on the efficacy of currently used insecticides for control of bed bugs.

Insecticide evaluations were conducted with bed bug samples collected from infested buildings across the U.S. Four different bed bug colonies were established in 2005-2006 from apartment buildings located in Lexington, KY (one colony) and Cincinnati, OH (three colonies). Other field collections were made in 2006-2007 from bed bug-infested dwellings in Kissimmee, FL; Vienna, VA; Smithtown, NY; Dover, NJ; Worcester, MA; Kalamazoo, Southfield, and Bloomfield Hills, MI; and Los Angeles, CA. Insecticide evaluations also were conducted with another laboratory colony, designated Ft. Dix; these bed bugs had not been exposed to pyrethroids for more than 30 years (Bartley and Harlan 1974).

Susceptibility was evaluated by confining adult or nymphal bed bugs on pyrethroid–treated filter paper. An F1 generation was produced by crossing virgin female bed bugs from the Ft. Dix laboratory colony with males from a pyrethroid resistant strain (CIN1). Deltamethrin and lambda cyhalothrin–two of the most popular pyrethroid active ingredients–were evaluated at varying concentrations and the resultant mortality determined after 24 hours of exposure. Dose-response analysis of mortality showed a dramatic difference in susceptibility to deltamethrin between the Ft. Dix colony and the four field colonies from the Kentucky–Ohio area (Romero et al. 2007a) For the field-derived colonies, the highest concentration that we evaluated (3.96 mg [AI]/cm^2) killed less than 5% of the individuals. The resistance ratio (RR) of these four colonies relative to the Ft. Dix colony was >12,765. The F1 offspring of matings between CIN1 and Ft. Dix showed intermediate levels of resistance (RR=1,481). This result suggested that the genetic basis of resistance was not a single dominant-recessive gene, but it was influenced by one or more genes with incomplete dominance (Romero et al. 2007a). The results with lambda-cyhalothrin paralleled those with deltamethrin. The CIN1 colony showed only 21.6% mortality at the highest concentration tested (1.32 mg [AI]/cm^2). Therefore, the resistance ratio was at least 6,123. Using a discriminating dose equivalent to 10 times the maximum labeled rate of deltamethrin (0.6 percent), 14 of 16 populations collected in Kentucky, Ohio, Michigan, New York, Massachusetts, Virginia, Florida, and California were categorized as resistant (Romero et al. 2007b). Bed bug populations resistant to pyrethroids have also been detected in the United Kingdom and Africa (Boase et al. 2006, Karunaratne et al. 2007). Difficulty in eliminating pyrethroid-resistant bed bugs could be a factor in the spread of infestations in the U.S. (Romero et al. 2007a). Pyrethroid resistance in bed bugs and the gradual regulatory reduction of traditional insecticides (chlorinated hydrocarbons, organophosphates, and carbamates) in many countries, demand the development of products with new modes of action and/or the optimization of the currently available insecticides.

The use of insecticide synergists may be an option to overcome resistance. Piperonyl butoxide (PBO), an inhibitor of cytochrome P450 monooxygenases, has been used extensively as a synergist of insecticides (Glynne-Jones 1998). We evaluated whether or not PBO enhanced deltamethrin toxicity in pyrethroid-resistant strains. The synergist (5% PBO) was delivered topically to individuals from two highly pyrethroid resistant strains (CIN-1 and WOR-1). Two hours later, PBO-treated individuals were exposed to a range of deltamethrin concentrations and mortality determined after 24 hour exposure. Reduction of resistance ratios in both strains (from RR>58,150 to 1,176 and 274, for CIN1 and WOR1, respectively) indicated that pretreatment with PBO enhanced toxicity of deltamethrin (Romero, unpublished data). However, incomplete suppression of resistance by PBO suggests that other mechanisms beside monooxygenase-mediated detoxification may be involved in pyrethroid resistance, including knockdown resistance (*kdr*) and/or other metabolic detoxification systems (Hemingway and Ranson 2000). Whether these mechanisms are partially responsible for resistance to deltamethrin in bed bugs needs to be investigated.

Another insecticide evaluated was a pyrrole, chlorfenapyr. In the U.S., chlorfenapyr is one the most common non-pyrethroid residual insecticides used for bed bug control (Potter 2008). Unlike pyrethroids that disrupt nerve transmission, chlorfenapyr uncouples oxidative phosphorylation processes in mitochondria (Hollingworth and Gadelhak 1998). Results from dry residue assays showed that chlorfenapyr was lethal to the six pyrethroid-resistant strains tested. However, the killing action of chlorfenapyr tended to be slow, requiring bugs to rest on the treated surfaces between 1 and 2 weeks to produce >80% mortality (Romero, unpublished data).

An area of intense investigation in our laboratory is the evaluation of sublethal effects of insecticides on biology and behavior of bed bugs. Typically the efficacy of an insecticide is defined by its lethal effects. However, because these compounds target the nervous and/or hormonal systems of insects, a complete understanding of their impact should consider their sublethal effects as well (Haynes 1988; Soderlund and Bloomquist 1989; Hamilton and Schal 1990). Thorough exposure of a population of insects to a lethal dose of an insecticide is not always possible. The issue of adequate coverage is exacerbated in an insect, such as the bed bug, that seeks out hidden refuges during the day. Biological (e.g., resistance and avoidance), abiotic factors (e.g., the nature of the substrate, temperature, humidity, light, decomposition and volatilization properties of the chemical), and accessibility of the bugs and their refuges may lead to sublethal rather than lethal exposure to insecticides (Rust et al. 1995). An initial apparently ineffective treatment could translate into a gradual decline in the population if host- and harborage-seeking behaviors are interrupted, or if egg laying declines after bugs contact insecticide residues. The full impact of insecticide applications on bed bug populations cannot be understood without an understanding of how the application affects egg-laying, host-finding, and harborage-seeking behaviors. For example, adverse effects on egg laying may result in effective, but delayed, control. Alternatively, insecticides may stimulate dispersal.

We evaluated responses of bed bugs to insecticides (deltamethrin and chlorfenapyr) with a number of behavioral assays. In two-choice tests, for example, bugs were offered one tent impregnated with the insecticide in acetone and the other with acetone alone (control) to determine whether insects avoid insecticide-treated areas. The acetone was allowed to evaporate. Results indicated that bed bugs may or may not avoid insecticide deposits, and this behavior depended on the insecticide tested. Insects tended to avoid dry residues of deltamethrin and preferred to rest in deltamethrin-free tents. On the other hand, bugs did not avoid dry deposits of chlorfenapyr (Romero, unpublished data). Avoidance of insecticides has been reported in cockroaches, which along with physiological resistance may be partly responsible for insecticide treatment failures (Lockwood et al. 1984, Hostetler and Brenner 1994). Our evaluations were further extended to establish whether bed bugs would avoid insecticide-treated harborages containing feces and other aggregating stimuli. Earlier studies suggested that bed bugs are driven by scent gland odors and feces to return to harborages and aggregations (Marx 1955). Aggregation is mediated by contact and airborne aggregation pheromones (Siljander et al. 2007, 2008). In our study, harborages remained attractive to bed bugs after being treated with Suspend® (deltamethrin). This indicated that either attracting or arresting factors were sufficient to overcome the avoidance of the pyrethroid. These findings correspond with field observations following Suspend® applications in which bed bugs were found resting in treated harborages (Romero et al. 2007b). The continued occupancy of such treated areas might increase exposure of bugs to the insecticide. In addition, bugs from strains that avoided deltamethrin deposits in the absence of any aggregating stimuli would crawl over deltamethrin or chlorfenapyr barriers to reach a heat source and take a blood meal. Moore and Miller (2006) reported no avoidance behavior of bed bugs to insecticides when a heat source was nearby. Our studies confirm that responses of bed bugs to a close-range heat source may take precedence over avoidance responses to deltamethrin.

Insecticides can affect locomotor activity of bed bugs. Analysis of video-recordings of bugs interacting with deltamethrin-treated surfaces showed an increase in locomotor activity when compared with bugs interacting with control tents. Hyperactivity caused by insecticides may increase the probability of bugs walking on insecticide-treated surfaces, which would promote the accumulation of insecticides and the subsequent lethal effect on susceptible populations. A different effect could be produced when individuals are resistant. In such cases, insecticides might encourage bugs to move into insecticide-free areas.

Our laboratory findings have shown that the behavioral responses of bed bugs to insecticides vary and depend on insecticide susceptibility, insecticide coverage, and other stimuli in the environment. Analysis of these factors might help us understand the effects of insecticides on bed bug populations.

References

Bartley, J. D., and H. J. Harlan. 1974. Bed bug infestation: its control and management, pp. 884–886. Military Medic. November 1974.

Boase, C. J., G. Small, and R. Naylor. 2006. Interim report on insecticide susceptibility status of UK bedbugs. Professional Pest Controller, Summer 2006: 6–7.

Glynne-Jones, D. 1998. Piperonyl Butoxide–The Insecticide Synergist. Academic Press, San Diego, CA.

Hamilton, R. H., and C. Schal. 1990. Sublethal effects of chlorpyrifos-methyl on reproduction in female German cockroaches (Dictyoptera: Blattellidae). J. Econ. Entomol. 83: 441–443.

Haynes, K. F. 1988. Sublethal effects of insecticides on the behavioral responses of insects. Annu. Rev. Entomol. 33: 149–168.

Hemingway, J., and H. Ranson. 2000. Insecticide resistance in insect vectors of human disease. Annu. Rev. Entomol. 45: 371–391.

Hollingworth, R. M. and G. G. Gadelhak. 1998. Mechanism of action and toxicity of new pesticides that disrupt oxidative phosphorylation. Reviews in Toxicol. 2: 253–266.

Hostetler, M. E., and R. J. Brenner. 1994. Behavioral and physiological resistance to insecticides in the German cockroach (Dictyoptera: Blattellidae): an experimental reevaluation. J. Econ. Entomol. 87: 885–893.

Karunaratne, S. H. P. P., B. T. Damayanthi, M. H. J. Fareena, V. Imbuldeniya, and J. Hemingway. 2007. Insecticide resistance in the tropical bedbug *Cimex hemipterus*. Pesticide Biochem. Physiol. 88: 102–107.

Lockwood, J. A., T. C. Sparks, and R. N. Story. 1984. Evolution of insect resistance to insecticides: a reevaluation of the roles of physiology and behavior. Bull. Entomol. Soc. Am. 30: 41–51.

Marx, R. 1955. Üeber die wirtsfindung und die bedeutung des artspezifischen duftstoffes bei *Cimex lectularius* Linné. Z. Parasitenk. 17: 41–73.

Moore, D. J., and D. M. Miller. 2006. Laboratory evaluations of insecticide product efficacy for control of *Cimex lectularius*. J. Econ. Entomol. 99: 2080–2086.

Potter, M. F. 2008. The business of bed bugs. Pest Mangt. Professional 76(1): 28–44.

Potter, M. F., A. Romero, K. F. Haynes, and W. Wickemeyer. 2006. Battling bed bugs in apartments. Pest Control Technol. 34: 44–52.

Romero, A., M. F. Potter; D. Potter, and K. F. Haynes. 2007a. Insecticide resistance in the bed bug: A factor in the pest's sudden resurgence? J. Med. Entomol. 44: 175–178.

Romero, A., M. F. Potter, and K. F. Haynes. 2007b. Insecticide-resistant bed bugs: implications for the industry. Pest Control Technol. 37(7): 42, 44, 46, 48, 50, 143.

Rust, M. K., J. M. Owens, and D. A. Reierson, eds. 1995. Understanding and Controlling the German Cockroach. Oxford University Press, New York, NY.

Siljander, E., D. Penman, H. Harlan, and G. Gries. 2007. Evidence for male– and juvenile-specific contact pheromones of the common bed bug *Cimex lectularius*. Entomol. Exp. Appl. 125: 215–219.

Siljander, E., R. Gries, G. Khaskin, and G. Gries. 2008. Identification of the airborne aggregation pheromone of the common bed bug, *Cimex lectularius*. J. Chem. Ecol. 34: 708–718

Soderlund, D. M. and J. R. Bloomquist. 1989. Neurotoxic actions of pyrethroid insecticides. Annu. Rev. Entomol. 34: 77–96.

SYMPOSIUM

TERMITE BEHAVIOR: BETTER UNDERSTANDING FOR BETTER CONTROL

21 May 2008

Organizer:
Bob Hickman (BASF Corporation)

TERMITE TUNNELS: INDIVIDUAL EXCAVATORS AND EMERGING PATTERNS

Paul Bardunias
University of Florida, Ft. Lauderdale, FL

The overall morphology of termite tunnel complexes has been quantified (Reinhard et al. 1997, Pitts-Singer and Forschler 2000, Campora and Grace 2001, Su and Puche 2003), but very little attention has been paid to the manner in which individual termites coordinate their digging efforts. All current models of termite construction are based on the concept of stigmergy (Grasse 1959), an indirect mode of communication between termites whereby the pheromone marked work product of a builder acts to guide the response of subsequent workers. Our investigation of termite excavation breaks with previous theories of construction. Rather than begin with the assumption that pheromone marking is integral to coordination, we assumed that pheromones play no part in the mechanics of tunnel excavation, relegating their role to the recruitment of a labor force to tunnels.

Herein we analyze the process of excavation in *Coptotermes formosanus* Shiraki at the level of the individual termite and describe the process of digging. Our study shows that the common motivations of individuals, sympraxis, in response to other termites and environmental cues, along with variation in the flux of workers within tunnels can provide a template for tunnel growth and form. We present a simple computer model of termite excavation, Simergate, based on our empirical data that demonstrates the emergence of branch formation from variations in traffic flow.

References

Campora, C. E., and J. K. Grace. 2001. Tunnel orientation and search pattern sequence of the Formosan subterranean termite (Isoptera: Rhinotermitidae). J. Econ. Entomol. 94: 1193-1199.

Grasse, P.-P. 1959. La reconstruction du nid et les coordinations inter-individuelles chez *Bellicositermes nataliensis* et *Cubitermes sp*. La theore de la stigmergie: essai d'interpretation du comportment des termites constructeurs. Insectes Soc. 6: 41-81.
Pitts-Singer, T. L., and B. T. Forschler. 2000. Influence of guidelines and passageways on tunnelling behavior of *Reticulitermes flavipes* (Kollar) and *R. virginicus* (Banks) J. Insect Beh. 13: 273-290.
Reinhard, J., H. Hertel, and M. Kaib. 1997. Systematic search for food in the subterranean termite *Reticulitermes santonensis* De Feytaud (Isoptera, Rhinotermitidae). Insectes Soc. 44: 147-158.
Su, N.-Y., and H. Puche. 2003. Tunneling activity of subterranean termites (Isoptera: Rhinotermitidae) in sand with moisture gradients. J. Econ. Entomol. 96: 88-93.

FOCAL ANIMAL SAMPLING USING FILM EXPLAINS THE MECHANICS OF WORKER BEHAVIORS IN *RETICULITERMES FLAVIPES* (KOLLAR) (ISOPTERA: RHINOTERMITIDAE)

Brian T. Forschler and Jefferson G. Whitman
Department of Entomology, University of Georgia, Athens, GA

Focal animal sampling provided the same behavioral repertoire for subterranean termites from two treatments, randomly-selected workers compared to subjects from intact colonies. Thirty-six individual *Reticulitermes flavipes* workers, six from each of six replicates, were scored for all visible behaviors observed during 15-min segments every other hour over three 24-h filming episodes for a total of 9 h per termite. Workers were scored for time spent and frequency in four behavioral categories: inactivity, grooming, feeding, and excavation. Subterranean termites spent approximately 73% of the time involved in no visible activity. Grooming accounted for 75% of the incidences of activity recorded indicating the importance of this behavior. Workers spent 17% of their 'active' time chewing materials which they consumed. Consumables were obtained from five different sources. Specific workers performed excavation. Termites in all replicates displayed a reduction in activity over time in bioassay. Treatments differed in frequency and time spent on behaviors relating to social communication including allogrooming, autogrooming, and autofeeding after allogrooming.

OBSERVATIONS OF SUBTERRANEAN TERMITE POPULATIONS OVER A THREE-YEAR PERIOD FROM A WILD LAND PLOT CONTAINING DIFFERENT SIZED FOOD RESOURCES

David Sillam-Dusses and Brian T. Forschler
Department of Entomology, University of Georgia, Athens, GA

A field study using food resources representing three size classes, a monthly collection schedule, and mitochondrial DNA (mtDNA) markers (cytochrome oxidase gene sequence − CO I and CO II) was conducted to examine the temporal and spatial distribution of *Reticulitermes* populations in 4 adjacent 187 m^2 plots located on Sapelo Island, GA (McIntosh County). The mtDNA (CO II gene) marker, indicating the progeny of a single adult female, was chosen by assuming a consensus sequence was representative of the basic building block of a subterranean termite colony. The data provide a 20-month view of the distribution and movement of *Reticulitermes* spp. populations in a wild land habitat. There was a correlation with consistency of termite detection and the size of the resource (larger resources

were more often occupied) when viewed at the level of a single plot, but on an individual basis, all resources were visited by multiple maternal lineages over time and/or at the same time. The data illustrate the dynamic nature of subterranean termite populations including interactions indicative of colony fusion, cooperation, and movement in addition to a spatial complexity beyond our expectations. The data in combination with previous work begs testing new hypotheses of *Reticulitermes* social structure that are in opposition to colony models based on territoriality.

SOCIAL INTERACTIONS AMONG *RETICULITERMES FLAVIPES* AND IMPLICATIONS AFTER EXPOSURE TO NON-REPELLENT TERMITICIDES WITH TRANSFER POTENTIAL

Xing Ping Hu
Department of Entomology and Plant Pathology, Auburn University, Auburn, AL

The in-ground and aboveground network and cryptic life of termites make it impossible to deliver control agents to the entire colony. Understanding of termite biology, behavior and ecology has lead to the use of baiting systems and non-repellent termiticides that take advantage of termite social interactions in order to amplify control efficiency. Our studies center on understanding the mechanisms whereby non-repellent termiticides cause population depression in *Reticulitermes flavipes*. Data indicate that control efficiency is achieved through a complicated process involving termite-termiticide and termite-contaminated termite interactions. The majority of termites are killed by direct contact or ingestion of termiticides in the bait and soil. Naïve termites acquire lethal doses from contaminated termites (‘lethal transfer’) through social interactions, including trophallaxis, grooming, fecal ingestion, cannibalism, necrophagy, etc. Rather than a one-time event, lethal dose uptake by termites is a result of repetitive, intricate non-continuous processes that include both termite-termiticide and termite-termite interactions. Lethal transfer is the only exposure route for individuals that remain in the nest area(s), such as reproductives and 1st and 2nd instar larvae. Recipient termites are responsible for initiating grooming and trophallaxis in most cases. Termites exhibit different behaviors towards different non-repellent termiticides. Many biotic and abiotic factors affect how termites acquire a lethal dose of a non-repellent termiticide.

SYMPOSIUM

EMERGING INVASIVE PEST ANTS OF IMPORTANCE

21 May 2008

Organizers:
Bob Davis and Bob Hickman
(BASF Corporation)

NATIVE SPECIES OF *LIOMETOPUM* EMERGING AS STRUCTURAL PESTS IN WESTERN NORTH AMERICA

Laurel D. Hansen
Biology Department, Spokane Falls Community College, Spokane, WA

Two native species of velvety tree ants have recently emerged as structural pests and are currently included in the list of wood-destroying organisms in western North America. *Liometopum occidentale* has been recorded as a pest species in the mountains of California and also in the Oregon/Washington areas of the Willamette Valley and Columbia Gorge. A second species, *Liometopum luctuosum*, also called the pine tree ant, is found in British Columbia, Washington, and Idaho usually at higher elevations. This species has been found at elevations from 400 m and higher, chiefly east of the Cascade Mountains.

Both species excavate wood and insulation in structures for nesting sites, and they feed on hemipteran secretions of honeydew. In structures, the ants are often found in areas with moisture such as in bathrooms and kitchens. These polygyne, polydomous ants are troublesome to manage because the colony moves from forested areas into structures in a short period of time. Structures have been observed where ants have been nesting for several years and other structures have been observed where ants invade within a 24-hour period. In the Pacific Northwest, velvety tree ants have been associated with hardwood trees and with many conifers such as western red cedar, Douglas fir, and pines.

Liometopum spp. are polymorphic and release a rotten coconut-like odor from anal glands when crushed. When disturbed these ants also raise their abdomen or ‘gaster flag’ in the process of releasing their alarm pheromone. Ants live in temporary nests or bivouacs and are aggressive biters. Swarming activity has not been observed.

Pest management professionals (PMPs) and homeowners have misidentified velvety tree ants as either odorous house ants or as carpenter ants. Velvety tree ants are polymorphic, but their size range overlaps that of the monomorphic odorous house ants. When crushed or disturbed, the coconut-like odor of velvety tree ants and odorous house ants is identical and many PMPs have improperly used this feature in identification. Field identifications can be made by comparison of nodes: velvety tree ants have a vertical node whereas the odorous house ant has a flat node. Confusion with carpenter ants occurs because of the extruded sawdust and insulation produced by the velvety tree ants. Both groups are considered wood-destroying organisms, but the excavations of the velvety tree ants are much finer than those of carpenter ants.

Velvety tree ants are managed with baits and perimeter sprays. Management is more difficult when ants occur in structures during the winter months when baits are not effective except for partial control with low concentrations of boric acid. Combinations of baits and perimeter sprays or perimeter sprays alone are effective treatments in early spring and summer.

References

Suomi, D. A., A. L. Antonelli, C. R. Foss. 2007. Structural pest inspector training manual. WSU Coop. Ext. MISC 0566.

Antonelli, A. L., T. L. Whitworth, C. A. Ramsey, C. R. Foss, and D. A. Suomi. 1998. Pest management study manual for pest control operators. WSU Coop. Ext. MISC 0096.

Gulmahamad, H. 1995. The genus *Liometopum* Mayr (Hymenoptera: Formicidae) in California, with notes on nest architecture and structural importance. Pan-Pacific Entomol. 71(2): 82-86.

Hansen, L. D. and J. H. Klotz. 1999. The name game can wreak havoc on ant control methods. Pest Control 67(6): 66, 68.

Hedges, S. A. 1998. Field guide for the management of structure-infesting ants. G.I.E. Publ., Cleveland, OH.

Merickel, F. W. and W. H. Clark. 1994. *Tetramorium caespitum* (Linnaeus) and *Liometopum luctuosum* W. M. Wheeler (Hymenoptera: Formicidae): new state records for Idaho and Oregon, with notes on their natural history. Pan-Pacific Entomol. 70(2): 148-158.

ROVER ANTS, *BRACHYMYRMEX PATAGONICUS*, IN MISSISSIPPI

M. Blake Layton and Joe A. MacGown
Mississippi State University, Mississippi State, MS

Brachymyrmex patagonicus is an invasive ant species thought to have originated in Argentina. It was first identified in the U.S. in 1976 in Louisiana and Florida. The following year it was also collected in northern Mississippi. Until recently this ant was often identified as *B. musculus*, or some other *Brachymyrmex* species, but MacGown recently examined specimens from several state collections and identified them as *B. patagonicus*. This identification was confirmed by Quiran, who recently re-described this species in Argentina. Ants of this genus are often referred to as 'rover ants'; the common name 'dark rover ant' has been proposed for *B. patagonicus*. Over the past 30 years this ant has expanded its range greatly. It is now one of the most common ant species through most of the southern gulf coastal region of the U.S. and its range continues to expand. These ants are common in both natural and urban settings and are an emerging pest species in urban settings. During the past decade, pest control companies complained of increased difficulty controlling little black ants, *Monomorium minimum,* but in practically all such cases where samples were submitted for identification, *B. patagonicus* was the species involved. Indoor infestations tend to be somewhat cryptic and often go unnoticed, except in sensitive accounts such as medical and food handling facilities.

THE THRIVING INVASION OF THE MEDICALLY IMPORTANT ASIAN NEEDLE ANT, *PACHYCONDYLA CHINENSIS* (EMERY)

Patricia A. Zungoli and Eric P. Benson
Department of Entomology, Soils, & Plant Sciences, Clemson University, Clemson, SC

Pachycondyla chinensis (Emery), the Asian needle ant, was first reported in North America by M.R. Smith in 1934. Since that first record in Georgia USA, the species has been documented in Washington, DC; Virginia; North Carolina; South Carolina; Tennessee; and Alabama. It is reported as indigenous to southeastern Asia, but it also is documented from other Oriental, Australasian and Palearctic locations.

When *P. chinensis* was first noted in the USA, it was described as occurring in colonies of several hundred individuals. Currently, in northwestern South Carolina it is known as a locally dominant species, occurring to the exclusion of expected fauna in some urban and forest habitats. It is not found in open grasslands or lawns, but rather it nests in shaded, protected sites beneath vegetation, mulch debris, rocks, or in urban habitats under man-made landscape objects in contact with the soil. Colonies sampled in our research sites in Pickens and Anderson Counties, SC, ranged in size from 40 to nearly 6,000 individuals. In South Carolina, workers of this species are active from March through October.

Using New Jersey light traps (Forestry Suppliers, Jackson, MS), *P. chinensis* swarming began in late May, peaked in early August, and declined sharply and quickly until activity ceased in September. A high ratio of male *P. chinensis* was collected in light trap samples, but it is unknown whether this is an artifact of the sampling technique or if males are the dominant alate form.

P. chinensis also is known for its ability to deliver a potent sting causing mild to severe allergic reactions. Anaphylaxis has been reported in the literature several times including twice in North America. Cases of anaphylaxis may have occurred on other occasions, but are not documented. Since *P. chinensis* workers are not aggressive and do not trail, it is very likely that some unknown sources of anaphylaxis are due to this species.

Mortality with insecticidal bait in the laboratory is variable due to inconsistent feeding. However, some baits may prove to be efficacious in the field. Other treatment data are limited, but results suggest that liquid treatments directly targeting nest sites are effective.

Acknowledgments

The authors appreciate the laboratory assistance of LayLa Burgess, Parks Edney, Theresa Pizzuto, Sonya Prosser, Jessee Wagner, and Sherri Wegner. This publication is Technical Contribution No. 5506 of the Clemson University Experiment Station.

THEY DON'T DIE...EASILY: THE TRUE STORY OF AN ECOLOGICALLY DOMINANT INVASIVE ANT IN TEXAS

Roger E. Gold and Jason Meyers
Texas A & M University, College Station, TX

A recent introduction of *Paratrechina* sp. nr. *pubens* to Houston, TX, has created significant economic impacts and become a great nuisance to the area. Populations of this ant have now been found in Texas in Harris, Galveston, Brazoria, Montgomery, and Wharton Counties. Few remedial treatments have been successful. The current studies include examination of various residential treatments. Trends in these data suggest supporting expansion of current label usage when combating infestations of this species.

PROGRAM

NCUE Program 2008

SUNDAY, MAY 18

2:30 pm — **Registration**
Strausbourg, marble counter in hall
Dr. Roger Gold, Texas A&M University

5:30 pm - 7:30 pm — **Welcome Reception**
Madrid II & III
Free hors d'oeuvres and cash bar

MONDAY, MAY 19

6:30 - 8:00 — **Breakfast**
Madrid II & III

7:00 — **Registration**
Strausbourg, marble counter in hall

8:15 — **Welcome and Orientation**
Salon IV
Richard Houseman, University of Missouri
Bob Cartwright, Syngenta Corporation

8:30 — **Distinguished Achievement Award in Urban Entomology**
Salon IV
Arnold Mallis Memorial Award Lecture
"…Bind the past, define the present, and predict the future…" - A sequel to *Subterranean termites: A personal perspective* by J. P. La Fage (1986)
NAN-YAO SU
University of Florida, Ft. Lauderdale REC

9:30 — **Student Scholarship Award Presentations**
Salon IV
Dini Miller, Virginia Tech
Robert Kopanic, SC Johnson & Son, Inc.

9:30 - 9:45 — **Master of Science Award**
Changes in diversity: A successional study of the pest ant species in Puerto Rican housing developments
PRESTON H. BROWN
Virginia Tech

9:45 - 10:00 — **Ph.D Award**
Bed bug research: Catching up with a forgotten pest
ALVARO ROMERO
University of Kentucky

10:00 — **Break**

2

10:30 **Student Paper Competition**
Salon IV
Paul W. Borth, Dow AgroSciences

10:30 - 10:40 **Efficacy of chlorfenapyr-treated wood to prevent colonization by dealates of the West Indian drywood termite, *Cryptotermes brevis***
MARIA TERESA FERREIRA and Rudolf Scheffrahn
University of Florida, Ft. Lauderdale REC

10:40 - 10:50 **The population expansion of pest ant species in the presence of *S. invicta* during stages of urban succession**
PRESTON H. BROWN, Dini M. Miller and Carlyle C. Brewster
Virginia Tech

10:50 - 11:00 **Indoxacarb toxicology in the German cockroach**
AMEYA D. GONDHALEKAR, Cheol Song and Michael E. Scharf
University of Florida

11:00 - 11:10 **Gene expression profiles of *Reticulitermes flavipes* in response to socio-environmental conditions**
MATTHEW R. TARVER and Michael E. Scharf
University of Florida

11:10 - 11:20 **Termite mediated alteration of food items**
NICOLA T. GALLAGHER and Susan C. Jones
Ohio State University

11:20 - 11:30 **Efficacy of broadcast formulations for control of the red imported fire ant (*Solenopsis invicta* (Buren)) in Virginia**
HAMILTON ALLEN and Dini Miller
Virginia Tech

12:00 **Awards Luncheon**
Madrid II & III

1:30 **Concurrent Session**
Submitted Papers: Cockroaches & General Pest
Salon IV
Moderator: Dina Richman, FMC

1:30 - 1:45 **Functional studies of cockroach allergens using post-transcriptional silencing of allergen genes by RNA interference**
COBY SCHAL, Alonso Suazo and J. Chad Gore
North Carolina State University

NCUE Program 2008

1:45 - 2:00 **Effect of spatial coverage with indoxacarb gel bait on cockroach populations in infested apartments**
COBY SCHAL and Richard G. Santangelo
North Carolina State University

2:00 - 2:15 **Effective cockroach management in problem accounts using Maxforce® FC Magnum Cockroach Bait Gel: Field and laboratory perspectives**
NONGGANG BAO, Deborah Koufas, Gary Braness, Joe Barile, Joe Hope and John Paige
Bayer Environmental Science

2:15 - 2:30 **Transport® GHP Insecticide: A new tool in the box for general household pest control**
DINA L. RICHMAN and Jim Walter
FMC Corporation

2:30 - 2:45 **Factors influencing refugia preferences by the recluse spiders *Loxosceles reclusa* and *Loxosceles laeta***
RICHARD S. VETTER and Michael K. Rust
University of California, Riverside

2:45 - 3:00 **Residual efficacy of MAXFORCE® Fly Spot Bait (imidacloprid 10 WG)**
D. KOUFAS, Nonggang Bao, John Paige, Gary Braness, Joe Barile and Vince Parman
Bayer Environmental Science

3:00 - 3:15 **Exempt products for the professional pest control market: Fads or the future?**
STEVE SIMS
Whitmire Micro-Gen Research Laboratories

3:15 - 3:30 **Borate mode of action on general pests**
JANET KINTZ-EARLY
Nisus Corporation

3:30 - 4:00 **Break**

1:30 **Concurrent Session**
Teaching Symposium: Getting Students Hooked on Bugs
Salon V
Organizers: Dini M. Miller, Virginia Tech and Eric Benson, Clemson University

1:30 - 2:00 **“Bug” students of all ages**
SUSAN C. JONES
Ohio State University

2:00 - 2:30 **No termite left behind: Meeting bench marks with insect science**
J. KENNETH GRACE, Erin Baumgartner, Julian R. Yates, III, and Maria Aihara-Sasaki
University of Hawaii at Manoa

2:30 - 3:00 **Exciting undergraduates with six-legged science**
ERIC BENSON and **PAT ZUNGOLI**
Clemson University

3:00 - 3:30 **Junior pest investigators: Teaching entomology and IPM, kindergarten to the eighth grade**
PATRICK COPPS
Orkin Pest Control

3:30 - 4:00 **Break**

4:00 - 4:30 **Why every entomologist should study urban entomology**
DINI MILLER
Virginia Tech

4:30 - 5:00 **Urban entomology - the future of the science**
ROGER GOLD
Texas A&M University

4:00 **Concurrent Symposium**
Symposium: Biodiversity of Termites from the Americas
Salon IV
Organizers: Allen.L.Szalanski, University of Arkansas and James W. Austin, Texas A&M University

4:00 - 4:20 **Phylogeography of *Reticulitermes* from the western United States**
ALLEN L. SZALANSKI
University of Arkansas, Fayetteville

4:20 - 4:40 **Identification and biogeography of termite species from Texas**
JAMES W. AUSTIN
Texas A&M University

4:40 - 5:00 **Patterns of endemnicity of New World termites**
TIM MYLES
University of Toronto

5:00 - 5:20 **Invasive termites in the Americas**
RUDOLF H. SCHEFFRAHN
University of Florida, Ft. Lauderdale REC

5:20 - 5:40 **Diversity and geographic distribution of termites in South America**
CANCELLED
REGINALDO CONSTANTINO
Universidade de Brasília

5:40 - 6:00 **Phylogeny and geological history of termites**
MICHAEL S. ENGEL
University of Kansas

6:00 **Dinner on Your Own**

TUESDAY, MAY 20

6:30 - 8:00 **Breakfast**
Madrid II & III

7:00 **Registration Open**
Strausbourg, marble counter in hall

8:00 **Concurrent Session**
Submitted Papers: Termites
Salon IV
Moderator: Paul Baker, University of Arizona

8:00 - 8:15 **A new approach to marking subterranean termites to study foraging and feeding population dispersal**
PAUL BAKER[1] and James Hagler[2]
[1] University of Arizona
[2] USDA-ARS, Arid Land Agricultural Research Center, Maricopa, Arizona

8:15 - 8:30 **Efficacy of the Exterra™ System with Labyrinth AC™ Termite Bait in Ohio field trials**
SUSAN C. JONES and Nicola T. Gallagher
Ohio State University

8:30 - 8:45 **Municipal termite control programs in Ontario, Canada**
TIMOTHY G. MYLES
Building Services, Guelph, Ontario

8:45 - 9:00 **Controlling termites using spot treatments and localized perimeter band applications of Premise® granules**
PHILIP MCNALLY, Vince Parman, Gary Braness, John Paige and Chip Anderson
Bayer Environmental Science

9:00 - 9:15 **Dose, distance and transfer effects of indoxacarb against the western subterranean termite (Isoptera: Rhinotermitidae)**
DONALD A. REIERSON[1], Raj K. Saran[2] and Michael K. Rust[1]
[1] University of California, Riverside
[2] McLaughlin Gormley King

9:15 - 9:30 **Sashimi: A component of the isopteran palate?**
JOE E. EGER, JR[1], Matt. T. Messenger[1], S. Buckley[1], L. Remmen[2], Allen L. Szalanski[3], and Jackie A. McKern[3]
[1] Dow AgroSciences,
[2] Sparta, NJ
[3] University of Arkansas, Fayetteville

9:30 - 9:45 **DNA analysis of subterranean termites in Delaware**
SUSAN KING and Carl Schmidt
University of Delaware

9:45 - 10:00 **Why wood-feeding termites could provide the better biofuels?**
JIANZHONG SUN
Mississippi State University, Coastal Research and Extension Center

10:00 - 10:30 **Break**

8:00 **Concurrent Session**
Submitted Papers: Ants & Bees
Salon V
Moderator: John Klotz, University of California, Riverside

8:00 - 8:15 **Efficacy of selected bait and residual toxicants for control of bigheaded ants, *Pheidole megacephala* (Hymenoptera: Formicidae), in large field plots**
JOHN WARNER, Rou-Ling Yang, and Rudolf H. Scheffrahn
University of Florida, Ft. Lauderdale REC

8:15 - 8:30 **Laboratory and field evaluations of four bait formulations for control of *Tapinoma sessile***
PRESTON H. BROWN and Dini M. Miller
Virginia Tech

8:30 - 8:45 **Advion baits and Optigard Ant Gel Bait reduce odorous house ant infestations around homes**
KAREN M. VAIL, Jennifer Chandler, Joey Morton and Pat Barnwell
University of Tennessee

8:45 - 9:00 **Urban pest management strategies for Argentine ants**
JOHN H. KLOTZ[1], Michael K. Rust[1], Herb C. Field[2], Les Greenberg[1] and Ken Kupfer[3]
[1] University of California, Riverside
[2] Lloyd Pest Control, San Diego, CA
[3] KM AntPro LLC, Nokomis, FL

9:00 - 9:15 **A longitudinal study of *Camponotus pennsylvanicus* (Hymenoptera: Formicidae) population structure: a preliminary report**
TRACIE M. JENKINS, Tyler D. Eaton and Dan Suiter
The University of Georgia, Griffin

9:15 - 9:30 **Indoxacarb as a management tool for carpenter ants**
LAUREL D. HANSEN
Spokane Falls Community College

9:30 - 9:45 **Horizontal transfer of indoxacarb in the German cockroach: Trophic cascade results in tertiary kill**
GRZESIEK BUCZKOWSKI [1], Clay Scherer [2], and Gary Bennett [1]
[1] Purdue University
[2] DuPont Professional Products

9:45 - 10:00: **Developing an Africanized honey bee emergency management education program for Florida**
WILLIAM H. KERN, JR.
University of Florida, Ft. Lauderdale REC

10:00 - 10:30 **Break**

10:30 **Concurrent Symposium**
Glimpse of Novel Chemistry/ Technology in Termite Management
Salon IV
Organizer: Shripat T. Kamble, U. Nebraska

10:30 **Introduction**
SHRIPAT T. KAMBLE
University of Nebraska, Lincoln

10:35 - 10:50 **Chlorantraniliprole: Exciting new chemistry from DuPont for termite control: Mode of action and potential as a termiticide**
CLAY SCHERER and Mark Coffelt
DuPont Professional Products

10:50 - 11:05 **Transport® termiticide insecticide: New chemistry for termite control**
DINA RICHMAN and James Ballard
FMC Professional Solutions

11:05 - 11:20 **Lufenuron termite bait**
CLARK LOVELADY, David Cox, Mark Zajac and Bob Cartwright
Syngenta Corporation

11:20 - 11:35 **Sense makes cents: How Halo And ESP sensory technologies are revolutionizing the termite market**
MARC FISHER and Matt Messenger
Dow Agrosciences

11:35 - 11:50 **Fastout™ Cs Foam - introduction and efficacy review of the first non-repellent ready-to-use broad-spectrum micro-encapsulated pyrethroid foam formulation**
JAMES CINK, Jonathan Berger, Kyle Jordan and Steven Sims,
Whitmire Micro-Gen

11:50 - 12:05 **Gene silencing as a tool for termite control?**
MICHAEL E. SCHARF
University of Florida

12:05 - 12:20 **Innovations and new technologies for management of subterranean termites – who needs them?**
NAN-YAO SU
University of Florida, Ft. Lauderdale REC

12:30 - 2:00 **Lunch On Your Own**

10:30 **Concurrent Symposium**
Assessment and Implementation of IPM in Schools
Salon V
Organizers : Dawn H. Gouge, University of Arizona, MAC Experiment Station; Tom Green, IPM Institute of North America, Inc. and Alexandre V. Latchininsky, University of Wyoming

10:30 - 10:55 **New tool to help schools calculate the costs of IPM**
MICHAEL E. MERCHANT[1], Blake Bennett[1], Janet A. Hurley[1], Kathy Murray[2], Belinda Messenger[3], Fudd Graham[4], Faith Oi[5] and Rebecca Baldwin[5]
[1] Texas AgriLife Extension,
[2] Maine Department of Agriculture
[3] California Department of Pesticide Reg.
[4] Auburn University
[5] University of Florida

10:55 - 11:20 **Advocacy, policy and regulation**
JANET HURLEY
Texas A&M University

11:20 - 11:45 **Assessment and implementation of IPM in schools: Practical implementation**
MARC LAME
Indiana University

11:45 - 12:10 **National Pest Management Strategic Plan for IPM in Schools**
TOM GREEN[1] and Dawn Gouge[2]
[1] IPM Institute of North America, Inc.
[2]University of Arizona, MAC Exp. Stn.

12:10 - 12:30 **Regional working groups**
LAWRENCE "FUDD" GRAHAM
Auburn University

NCUE Program 2008

2:00 **Concurrent Session**
Submitted Papers: Powderpost Beetles, Formosan Termites & Other New Orleans' Pests
Salon IV
Moderator: Dan Suiter, University of Georgia

2:00 - 2:15 **Anobiid powderpost beetles in an infested crawlspace: Results of a two-year study**
DANIEL R. SUITER and Tyler D. Eaton
University of Georgia, Griffin

2:15 - 2:30 **Effect of anti juvenile hormone agents and biogenic amines on Formosan subterranean termite soldier formation**
LIXIN MAO, Shauanglin Dong and Gregg Henderson
LSU AgCenter

2:30 - 2:45 **Aggressive interactions between Formosan subterranean termite colonies from New Orleans, Louisiana**
MARY L. CORNELIUS and Weste L. A. Osbrink
USDA-ARS, Southern Regional Research Center (SRRC)

2:45 - 3:00 **Overcoming obstacles to successful area-wide control of Formosan subterranean termites in New Orleans' French Quarter**
FRANK S. GUILLOT[1], Dennis R. Ring[2], and Alan R. Lax[1]
[1]USDA-ARS, SRRC
[2] The LSU Agricultural Center, Louisiana State University

3:00 - 3:15 **New approach to area-wide management of the Formosan subterranean termite (*Coptotermes formosanus*) in Louisiana**
KEN S. BROWN[1], Claudia Riegel[1], Frank Guillot and M. K. Carroll[1]
[1] City of New Orleans Mosquito and Termite Control Board (NOMTCB)
[2] USDA-ARS, SRRC

3:15 - 3:30 **Inspections of trees and properties in managing the Formosan subterranean termite in the French Quarter program, New Orleans, Louisiana**
DENNIS R. RING[1], Alan L. Morgan[1], Frank S. Guillot[2], Alan R. Lax[2], Charles R. McCown[1] and Claudia Reigel[3]
[1] Louisiana State University Agricultural Center
[2] USDA-ARS, SRRC
[3] NOMTCB

3:30 - 4:00 **Break**

4:00 - 4:15 **Louisiana pilot program for Bora-Care new construction treatments**
JANET KINTZ-EARLY
Nisus Corporation

4:15 - 4:30 **Post-Katrina pest ants in South Louisisana**
LINDA BUI, Beverly Wiltz, K. Baudier and Rachel Strecker
Louisiana State University

2:00 **Concurrent Symposium**
Blood-Sucking Hitchhikers – the Return of Fleas and Ticks
Salon V
Organizers: Deanna Branscome, Syngenta Home Care and Phil Koehler, University of Florida

2:00 - 2:15 **Introduction**
DEANNA BRANSCOME
Syngenta Home Care

2:15 - 2:40 **The diversity of urban fleas (Siphonaptera) and their natural history in the southeastern United States**
BILL KERN
University of Florida, Ft. Lauderdale REC

2:40 - 3:05 **How flea biology and behavior impact control strategies**
NANCY HINKLE
University of Georgia

3:05-3:30 **Ecology and management of ticks in the urban environment**
PETE TEEL
Texas A&M University

3:30 - 4:00 **Break**

4:00 **Submitted Papers**
Public Health Pests
Salon V
Moderator: **ELLEN THOMS,** Dow Agro Sciences

4:00 - 4:15 **Bed bug management: Practical experiences in the field and a response to insecticide resistance**
BYRON L. REID and Joe Barile
Bayer Environmental Science

4:15 - 4:30 **Pre- and post-eclosion of bed bug (*Cimex lectularius*) eggs using various compounds**
ERIC J SNELL, Todd Smith and Wally Sexton, Snell Scientifics LLC

NCUE Program 2008

4:30 - 4:45 **Evaluation of effect of truck cargo container configuration, sealing method and duration of fan operation on confinement of Vikane® gas fumigant (sulfuryl fluoride)**
ELLEN THOMS[1] and Rudolf Scheffrahn[2]
[1]Dow AgroSciences LLC
[2]University of Florida, Ft. Lauderdale REC

4:45 - 5:00 **Bed bug insecticide research: What have we learned?**
ALVARO ROMERO, Michael F. Potter and Kenneth F. Haynes
University of Kentucky

6:00 - 9:00 **Evening Reception, Philbrook Museum of Art, student paper competition awards presented**

WEDNESDAY, MAY 21

6:30 - 8:00 **Breakfast**
Madrid II & III

7:00 **Registration**
Strausbourg, marble counter in hall

8:30 **Concurrent Symposium**
Termite Behavior: Better Understanding for Better Control
Salon IV
Organizer: Bob Hickman, BASF Corporation

8:30 - 8:35 **Introduction**
BOB HICKMAN
BASF Corporation

8:35 - 8:55 **Termite tunnels: Individual excavators and emerging patterns**
PAUL BARDUNIAS
University of Florida, Ft. Lauderdale REC

8:55 - 9:15 **Focal animal sampling using film explains the mechanics of worker behaviors in *Reticulitermes flavipes* (Kollar) (Isoptera: Rhinotermitidae)**
BRIAN T. FORSCHLER and Jefferson G. Whitman
University of Georgia

9:15 - 9:35 **Observations of subterranean termite populations over a three year period from a wild land plot containing different sized food resources.**
DAVID SILLAM-DUSSES and Brian T. Forschler
University of Georgia

9:35 - 9:55	**Social interaction among *R. flavipes* and implications after exposure to nonrepellent termiticides with transfer potential** **XING PING HU** Auburn University
9:55 - 10:15	CANCELLED **A look into the secret life of the western drywood termite** **BRIAN J. CABRERA** Santa Barbara County Agricultural Commissioner's Office
8:30	**Concurrent Symposium** **Emerging Invasive Pest Ants of Importance** *Salon V* Organizers: Bob Davis and Bob Hickman, BASF Corporation
8:30 - 8:35	**Introduction** **BOB DAVIS** BASF Corporation
8:35 - 8:55	**Native species of *Liometopum* emerging as structural pests in western North America** **LAUREL D. HANSEN** Spokane Falls Community College
8:55 - 9:15	**Rover ants, *Brachymyrmex patagonicus*, in Mississippi** **M. BLAKE LAYTON** and Joe A. MacGown Mississippi State University
9:15 - 9:35	**The thriving invasion of the medically important Asian needle ant, *Pachycondyla chinensis* (Emery)** **PATRICIA ZUNGOLI** and Eric Benson Clemson University
9:35 - 9:55	**They don't die...easily: The true story of an ecologically dominant invasive ant in Texas** **ROGER GOLD** and Jason Meyers Texas A&M University
10:30	**Business Meeting**
11:15	**Executive Committee Business Meeting**

Past Recipients of the Distinguished Achievement Award in Urban Entomology

1986	Walter Ebeling, James Grayson
1988	John V. Osmun, Eugene Wood
1990	Francis W. Lechleitner
1992	Charles G. Wright
1994	Roger D. Akre, Harry B. Moore, Mary H. Ross
1996	Donald G. Cochran
1998	Gary W. Bennett
2000	Michael K. Rust
2004	Roger E. Gold
2006	Coby Schal

Past Conference Chairs

1986	Patricia A. Zungoli
1988	William H. Robinson
1990	Michael K. Rust
1992	Gary W. Bennett
1994	Roger E. Gold, Judy K. Bertholf
1996	Donald A. Reierson
1998	Brian T. Forschler, Shripat Kamble
2000	Shripat Kamble
2004	Daniel R. Suiter
2006	Dini Miller, Bob Kopanic

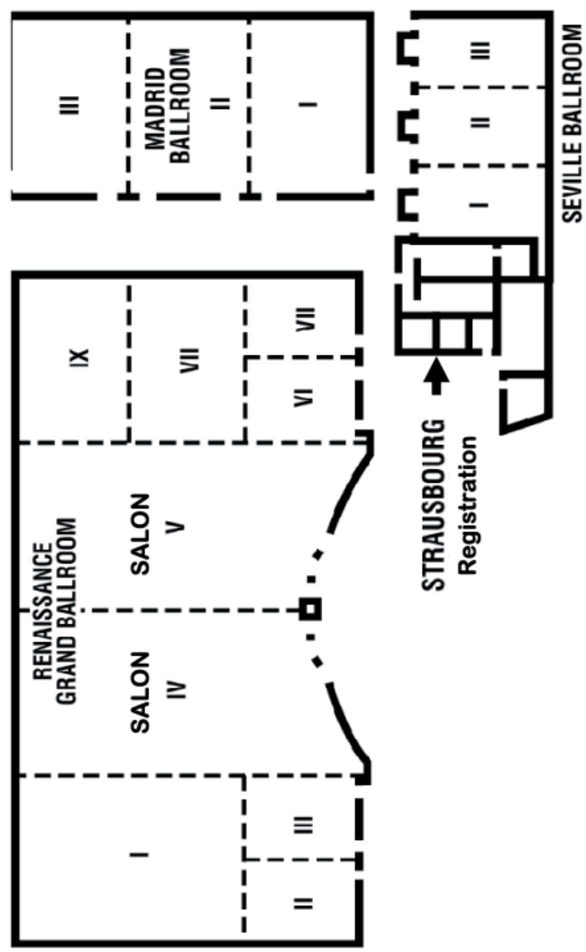
2008 National Conference on Urban Entomology Planning Committee

RICHARD HOUSEMAN, University of Missouri, Conference Co-Chair/ **BOB CARTWRIGHT**, Syngenta, Conference Co-Chair/ **KAREN VAIL**, University of Tennessee, Program & Proceedings Co-Chair/ **BRIAN CABRERA**, Santa Barbara County Agricultural Commissioner's Office, Program & Proceedings Co-chair/ **SUSAN JONES**, Ohio State University, Program & Proceedings/ **BOB HICKMAN**, BASF, Program & Proceedings/ **BRAD KARD**, Oklahoma State University, Local Arrangements, Co-Chair/ **JIM CRISWELL**, Oklahoma State University, Local Arrangements, Co-chair/ **ROGER GOLD**, Texas A&M University, Secretary-Treasurer/ **SHRIPAT KAMBLE**, University of Nebraska, Sponsorship Co-chair/ **GARY BENNETT**, Purdue University, Sponsorship Co-chair/ **BILL MCCLELLAN**, DuPont, Sponsorship/ **DINI MILLER**, Virginia Tech, Awards/ **ROBERT KOPANIC**, S.C. Johnson & Son, Inc., Awards / **WILLIAM KERN**, University of Florida, Awards / **PAUL W. BORTH**, Dow AgroSciences, Student Paper Competition

Corporate Sponsors
To be a corporate sponsor of the National Conference on Urban Entomology is to be a benefactor of programs supported by the conference, a supporter of current entomological activities in the areas of urban entomology, and a partner in promoting a better understanding of the science of urban entomology. The following are the National Conference on Urban Entomology Corporate Sponsors for 2008 (in alphabetical order):

BASF Corporation
Bayer Environmental Science
Dow AgroSciences
DuPont Professional Products
MGK-McLaughlin Gormley King Company
Orkin
PCT Pest Control Technology Magazine
Pest Management Professional Magazine
S.C. Johnson & Son Inc.
Syngenta
Terminix
Whitmire Micro-Gen

2008 National Conference on Urban Entomology May 18 – 21



Renaissance Tulsa Hotel and Convention Center Tulsa, OK

2008 National Conference on Urban Entomology Planning Committee

Richard Houseman (University of Missouri), Conference Co-Chair

Bob Cartwright (Syngenta), Conference Co-Chair

Karen M. Vail (University of Tennessee), Program and Proceedings

Brian J. Cabrera (Santa Barbara County), Program and Proceedings

Susan C. Jones (Ohio State University), Program and Proceedings

Bob Hickman (BASF), Program and Proceedings

Brad Kard (Oklahoma State University), Local Arrangements

Jim Criswell (Oklahoma State University), Local Arrangements

Jerry Bowen (Oklahoma State University), Local Arrangements (IT Support)

Roger E. Gold (Texas A&M University), Secretary-Treasurer

Laura Nelson (Texas A&M University), Assistant to Roger Gold

Shripat T. Kamble (University of Nebraska), Sponsorship

Gary W. Bennett (Purdue University), Sponsorship

Bill McClellan (DuPont), Sponsorship

Dini M. Miller (Virginia Tech), Awards

Robert Kopanic (S.C. Johnson & Son), Awards

William H. Kern, Jr. (University of Florida), Awards

Paul Borth (Dow AgroSciences), Student Paper Competition

2010 National Conference on Urban Entomology Planning Committee

Karen M. Vail (University of Tennessee), Conference Chair

Faith M. Oi (University of Florida), Program and Proceedings

Laurel D. Hansen (Spokane Falls Community College), Local Arrangements

Tom Nishimura (BASF), Local Arrangements

Dini M. Miller (Virginia Tech), Secretary

Shripat T. Kamble (University of Nebraska), Co-Treasurer

Roger E. Gold (Texas A&M University), Co-Treasurer

Laura Nelson (Texas A&M University), Assistant to Roger Gold

Dan Suiter (University of Georgia), Sponsorship

Gary W. Bennett (Purdue University), Sponsorship

Bill McClellan (DuPont), Sponsorship

Bob Cartwright (Syngenta), Awards

Richard Houseman (University of Missouri), Awards

Recipients Of The Distinguished Achievement Award In Urban Entomology

1986	Dr. Walter Ebeling (University of California, Los Angeles) Dr. James Grayson (Virginia Polytechnic Institute & State University)
1988	Dr. John V. Osmun (Purdue University) Dr. Eugene Wood (University of Maryland)
1990	Dr. Francis W. Lechleitner (Colorado State University)
1992	Dr. Charles G. Wright (North Carolina State University)
1994	Dr. Roger D. Akre (Washington State University) Dr. Harry B. Moore (North Carolina State University) Dr. Mary H. Ross (Virginia Polytechnic Institute & State University)
1996	Dr. Donald G. Cochran (Virginia Polytechnic Institute & State University)
1998	Dr. Gary W. Bennett (Purdue University)
2000	Dr. Michael K. Rust (University of California, Riverside)
2004	Dr. Roger E. Gold (Texas A&M University)
2006	Dr. Coby Schal (North Carolina State University)
2008	Dr. Nan-Yao Su (University of Florida)

NCUE Conference Chairs

1986	William H. Robinson (Virginia Polytechnic Institute & State University)
1988	Patricia A. Zungoli (Clemson University)
1990	Michael K. Rust (University of California, Riverside)
1992	Gary W. Bennett (Purdue University)
1994	Roger E. Gold (Texas A&M University) Judy K. Bertholf (DowElanco)
1996	Donald A. Reierson (University of California, Riverside)
1998	Brian T. Forschler (University of Georgia) Shripat T. Kamble (University of Nebraska)
2000	Shripat T. Kamble (University of Nebraska)
2004	Daniel R. Suiter (University of Georgia)
2006	Dini M. Miller (Virginia Tech University) Bob Kopanic (S.C. Johnson)
2008	Richard Houseman (University of Missouri) Bob Cartwright (Syngenta)

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 scholarship.

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 and extension programs related to urban and structural entomology.
3. To prepare a written 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. Two levels of scholarships will be offered: the first level is for Bachelors and Masters degree students; the second level is for Ph.D. candidates. 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.

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, printing of proceedings and the offering of scholarships. All persons with an interest in urban entomology are invited as members to attend the conferences and associated events.

ARTICLE VI-OFFICERS
Leadership for the Conference will be provided by a Steering Committee composed primarily of representatives from academia, but may include pest control professionals from industry and government. There will be seven officers including: Chair of the Steering Committee, Chair of the Program Committee, Secretary/Treasurer, Chair of the Sponsorship Committee, Chair of the Awards Committee, Chair of the Local Arrangements Committee, and an Industry Representative. The Chair of the Steering Committee will preside at all Steering Committee Meetings and will be the Executive Officer for the organization and will preside at meetings. In the absence of the Chair of the Steering Committee, the Chair of the Program Committee may preside. The voting members for executive decisions of the conference will be by 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 overseeing the printing of announcements, programs and proceedings.

Secretary/Treasurer: To provide minutes of meetings, documentation of expenditures and the collection and disbursement of funds.

Chair For Sponsorship: To contact contributors and potential contributors to seek donations and support for the conference and associated events.

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

Chair For Local Arrangements: To act on behalf of the executive committee in making arrangements with hotels, convention centers and other facilities in which conferences are held. To arrange for audio/visual equipment and to oversee the general physical arrangements for the conference.

Industry Representative: To be the liaison between the commercial manufacturers and distributors of pest control products and the Conference Steering Committee. This position will also be involved in fund raising and in seeking sponsorship for various aspects of the conference.

ARTICLE VI-TERMS OF OFFICE
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 Conference Chair may serve for one conference after which time they will become the Chair of the Awards Committee. The Chair for Local Arrangements should change with each

conference unless the meetings are held in the same location. The Chair of both the Sponsorship Committee and the Industry Representative will serve for two conferences. The Secretary/Treasurer will serve for two conference cycles, unless reappointed by the steering committee.

ARTICLE VII-COMMITTEES
The standing committees are as follows:

1. Conference Steering Committee-Composed of the seven officers as described above, and chaired by the Chair of the Conference.
2. Nomination Committee: Chaired by Chair of Conference Committee
3. Program Committee: Chaired by Chair of Program Committee
4. Sponsorship Committee: Chaired by Chair of Sponsorship Committee
5. Awards Committee: Chaired by Chair of Awards Committee
6. Local Arrangements Committee: Chaired by Chair for Local Arrangements
7. Industry Representative Committee: Chaired by Industry Representative
8. Other ad hoc committees may be formed as needed, but will not be maintained longer than one year.

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 Nominations Committee (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 Nomination Committee. In the event that there are no nominations, the existing Chair may remain in office with a majority vote of the Steering 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 Urban Entomology Conference”. Expenditures may be made in support of the conference, for scholarships and other reasonable costs; however, funds may not be used to pay officers of the organization for their time or ordinary 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.

2008 NCUE Closing Business Meeting Minutes

Wednesday, May 21, 2008 (10:00-11:15 am)
Renaissance Tulsa Hotel and Convention Center
Tulsa, OK

In attendance: approximately 40-50 people. (there were about 50+50 in Wed's am meetings)
Lead by Richard Houseman.

1. Thanks to all who attended this year's meeting (we had 180 pre-registered this time, with 17 add'l, onsite) (This is down from 250 in '06 and '04)

2. Thanks to the sponsors who donated funds.

3. Anticipated amount to carry forward to 2010's meeting will be approx. $50,000.

4. Proceedings will be printed and mailed to the 200 people who attended, but anyone else who wants one will be able to print it (pdf) from the website. Susan Jones will prepare the Proceedings. Presenters have until July 1st to submit their summary for inclusion. Laura will mail her the already addressed envelopes.

5. The meeting will continue in 2010, and the committee has any issues/proposals concerning the continuation of this meeting? (ESA?)
Paul Borth will check into the details on becoming a network with ESA.

6. If there is a consensus to continue, discuss the slate of officers.

7. Location has been decided that it will be in Portland, OR.

8. Time of year (3rd week in May has always worked for most people)

9. Any business items to discuss? Open forum from floor.
Ellen Thoms—include travel grants for students?
Keep meeting 2.5 days. If ends earlier, people will still leave.
Begin Sunday and end at noon on Wed.
Continue Tue's excursion.
Do all the awards at Tue's excursion instead of having an award's lunch?
Continue the informality of Tue's excursion—keep it as it is now.
No posters—logistical and cost issues
Clay Scherer: move to weekdays instead of weekends?
Linda Bui: <u>Student scholarship issue</u>. The timing of finishing up their degree is a problem. Most awards are going to those who are 6-12 months from finishing, and since this is every 2 years, there is discrimination against a group of students who just started. Change the criteria??
Shripat Kamble: category separation? MS, Ph.D.? (It already is)
Dini Miller will look at the wording of the criteria.
Bob Davis & Gary Bennett: it needs to be adjusted. Need to expand the window.
Richard Houseman and Bob Cartwright will look at it and see if it can be fixed.
Concurrent sessions—<u>moderators need to take better control</u> and the speakers need to rehearse. The moderators have got to be strong. It was hard to change back and forth between sessions.
Bill McClellan: talks were too short to cover all of the topics.

10. Any changes to the by-laws?
Include research awards, in addition to student scholarships?
Roger Gold: will involve providing 1099's to recipients.
Motion was made by Linda Bui to have the ability to expand the awards to include research. Motion was seconded by Bill Donahue. Motion carried, with 2 no's.
It will to the Award Committee to decide and work out. The Committee does not have to do this, but it CAN, if it decides to. It can be worded something to the effect of "Scholarship and research awards".

11. Any resolutions to add to the minutes?

The meeting went very smoothly and was a very good conference.

Meeting adjourned at 11:15am.

Letter Certifying Compliance with IRS Filing Requirements

Thompson, Derrig & Craig, P.C.

CERTIFIED PUBLIC ACCOUNTANTS

Woody Thompson, CPA/CFP
Ronnie Craig, CPA
Dillard Leverkuhn, CPA

Andrea Derrig, CPA

4500 Carter Creek Parkway, Suite 201
Bryan, Texas 77802-4456
(979) 260-9696 - Fax (979) 260-9683
email: firm@tdccpa.com

Sandy Beavers, CPA
Alline Briers, CPA
Gay Vick Craig, CPA
Kay Dobbins, CPA
Lyn Kuciemba, CPA
Alice Monroe, CPA
Jamie Reeves, CPA
Marian Rose Varisco, CPA

May 8, 2008

National Conference of Urban Entomology
Board of Directors
c/o Texas A&M University
Center for Urban and Structural Entomology
2143 TAMU
College Station, TX 77843-2143

For the 2007 tax year a Form 990-EZ will not be required to be filed. The organization's average annual gross receipts for the three-year period of 2005, 2006, and 2007 are less than the $25,000 threshold that requires a return to be filed.

Sincerely,

Dillard Leverkuhn, CPA

List of Attendees
2008 National Conference on Urban Entomology
May 18 - 21, 2008
Tulsa, OK

Hamilton Allen
Virginia Tech
216A Price Hall
Blacksburg, VA 24061
541-231-4045
hrallen@vt.edu

Chip Anderson
Bayer Environmental Science
805 South Glynn Street, St. 127 PMB 410
Fayetteville, GA 30214
404-401-4975
chip.anderson@bayercropscience.com

James Austin
Texas A&M University
2143 TAMU
College Station, TX 77843-2143
979-845-5855
jwaustin@ag.tamu.edu

Paul Baker
University of Arizona
Forbes Bldg., Rm 410
Tucson, AZ 85721
520-626-7366
pbaker@ag.arizona.edu

Nonggang Bao
Bayer Environmental Science
981 NC Hwy 42E
Clayton, NC 27527
919-262-0208
nonggang.bao@bayercropscience.com

Paul Bardunias
University of Florida
302 College Ave.
Fort Lauderdale, FL 33314
954-336-6335
paulmb@ufl.edu

Joe Barile
Bayer Environmental Science
7 Noreen Rd.
Mansfield, MA 02048-3704
508-339-2792
joe.barile@bayercropscience.com

Kaitlin Baudier
Louisiana State University
404 Life Sciences Bldg.
Baton Rouge, LA 70803
225-578-7149
kbaudi1@lsu.edu

Anastasia Becker
Missouri Dept. of Agric.
1616 Missouri Blvd.
Jefferson City, MO 65109
573-526-0837
anastasia.becker@mda.mo.gov

Brian Beidle
The Steritech Group
517 Cielo Vista Dr.
Greenwood, IN 46143
brian.beidle@steritech.com

Gary Bennett
Purdue University
Dept. of Entomology
West Lafayette, IN 47907
765-494-4564
gbennett@purdue.edu

Eric Benson
Clemson University
Dept. ESPS
114 Long Hall
Clemson, SC 29634-0315
864-656-3111
ebenson@clemson.edu

Jonathan Berger
Whitmire Micro-Gen Res. Lab
3568 Tree Court Industrial Blvd.
St. Louis, MO 63122
636-861-4239
jonathan.berger@wmmg.com

Don Bieman
San Pedrito Institute
HC-44 Box 13444
Cayey, PR 00736
787-644-0604
dnbspi@caribe.net

Judy Black
The Steritech Group
5742 W. 114th Place
Broomfield, CO 80020
judy.black@steritech.com

Paul Borth
Dow AgroSciences
9330 Zionsville Rd. 308/3A
Indianapolis, IN 46268
317-337-3592
pwborth@dow.com

Gary Braness
Bayer Environmental Science
7666 N. Atkins Pl.
Kansas City, MO 64152
816-853-0522
gary.braness@bayercropscience.com

Deanna Branscome
Syngenta Prof. Products
1313 Abbott Lane
Sebastian, FL 32958
772-403-3829
deanna.branscome@syngenta.com

Ken Brown
City of New Orleans Mosquito &
Termite Control
6601 Stars & Stripes Blvd.
New Orleans, LA 70126
504-415-7140
ksbrown@cityofno.com

Preston Brown
Virginia Tech
216A Price Hall
Blacksburg, VA 24061
276-698-8608
prbrown@vt.edu

John Bruce
Syngenta Prof. Products
2207 Knoll Ridge Drive
Corinth, TX 76210
800-232-5549 ext. 5837
john.bruce@syngenta.com

Jennifer Brumfield
Western Industries, North
P.O. Box 367
Parsippany, NJ 07054-0367
973-515-0100
jbrumfield@westernpest.com

Linda Bui
Louisiana State University
404 Life Sciences Bldg.
Baton Rouge, LA 70803
225-578-7149
lhooper@agcenter.lsu.edu

Bryce Bushman
Texas A&M University
2143 TAMU
College Station, TX 77843-2143
979-845-5855

Ron Cardoza
Bio Research
1738 N. Fowler Ave.
Fresno, CA 93727
559-455-5660
ron.cardoza@bio-research.net

Bob Cartwright
Syngenta Prof. Products
8731 Coppertowne Lane
Dallas, TX 75243
214-507-1894
bob.cartwright@syngenta.com

Michael Chapman
Steritech
1856 Spahn Ln.
Placentia, CA 92870
714-393-1451
mschapman@sbcglobal.net

James H. Cink
Whitmire Micro-Gen
3568 Tree Court Industrial Blvd.
St. Louis, MO 63122
636-861-4254
jim.cink@wmmg.com

Stewart Clark
Senet Chemical-Terro Ant Killer
566 Leffingwell Ave.
St. Louis, MO 63122
314-698-5030

Mark Coffelt
DuPont Corp.
5916 Wild Orchid Tr.
Raleigh, NC 27613
916-676-2783
mark.a.coffelt@usa.dupont.com

Larry Coltharp
Black Flag Brands
742 Horizon Dr.
Martinez, CA 94553
925-229-1458

Pat Copps
Orkin
1049 Regatta Run
Costa Mesa, CA 92627
pcopps@rollins.com

Mary Cornelius
USDA/ARS
1100 Robert E. Lee Blvd.
New Orleans, LA 70124
504-286-4449
mary.cornelius@ars.usda.gov

David Cox
Syngenta Prof. Products
14446 Huntington Rd
Madera, CA 93636
559-822-4597
david.cox@syngenta.com

Jim Criswell
Oklahoma State University
127 NRC
Stillwater, OK 74078
405-744-5531
jim.t.criswell@okstate.edu

Hope Dalton
Western Industries, North
P.O. Box 367
Parsippany, NJ 07054-0367
973-515-0100
hdalton@westernpest.com

Bob Davis
BASF Specialty Products
2605 Butler National Dr.
Pflugerville, TX 78660
512-989-5618
robert.davis@basf.com

Adalberto Perez deLeon
Valent BioSciences Corp.
870 Technology Way
Libertyville, IL 60048
847-968-4836
beto.perez@valent.com

Joe DeMark
Dow AgroSciences
9330 Zionsville Rd. 308/3A
Indianapolis, IN 46268
317-337-7522
jjdemark@dow.com

Bill Donahue
Sierra Research Laboratories
5100 Parker Rd.
Modesto, CA 95357
209-521-6380
srl@clearwire.net

Leanne Donahue
Sierra Research Laboratories
5100 Parker Rd.
Modesto, CA 95357
209-521-6380
srl@clearwire.net

Tyler Eaton
University of Georgia
1109 Experiment St., Cowart Bldg.
Griffin, GA 30223
770-228-7343
eaton@uga.edu

Joe Eger
Dow AgroSciences
2606 S. Dundee St.
Tampa, FL 33629
813-835-8358
jeeger@dow.com

Michael Engel
University of Kansas
Natural History Museum
501 Crestline Dr-St. 140
Div. of Entomology
Lawrence, KS 66049
785-864-4540
msengel@ku.edu

Harlan Feese
EcoSmart
3600 Mansell Rd., St. 150
Alpharetta, GA 30022
314-698-5030
hfeese@ecosmart.com

Maria Ferreira
University of Florida
3205 College Ave.
Fort Lauderdale, FL 33314
954-643-3238
mteresa@ufl.edu

Michael Folkins
XT-2000
6328 Riverdale
San Diego, CA 92120
866-870-8485
mfolkins@xt2000.com

Dan Forey
Bio Research
1738 N. Fowler Ave.
Fresno, CA 93727
559-455-5660
dn.forey@bio-research.net

Brian Forschler
University of Georgia
Dept. of Entomology
Athens, GA 30602
706-542-4282
bfor@uga.edu

John Fortino
Bayer Environmental Science
2875 Ashmont Dr.
Germantown, TN 38138
901-754-8507
john.fortino@bayercropscience.com

Brenda Franke
DuPont Corp.
4417 Lancaster Pike
Wilmington, DE 19880
302-999-5423
brenda.g.franke@usa.dupont.com

Austin Frishman
AMF Pest Management Services
17647 Sealakes Dr.
Boca Raton, FL 33498
561-487-1585

Nicky Gallagher
Ohio State University
1991 Kenny Rd.
Columbus, OH 43210
614-247-5029
gallagher.155@osu.edu

Roger Gold
Texas A&M University
2143 TAMU
College Station, TX 77843-2143
979-845-5855
r-gold@tamu.edu

Julie Gold
Texas A&M University
College Station, TX 77843

Norman Goldenberg
Terminix Int’l
860 Ridge Lake Blvd.
Memphis, TN 38120
901-277-8443
ngoldenberg@terminix.com

Ameya Gondhalekar
University of Florida
Bldg 970 Natural Area Dr.
Gainesville, FL 32611
352-392-1901 ext. 200
ameygon@ufl.edu

F. Carter Gordon
BASF Corp.
26 Davis Drive
Research Triangle Park, NC 27709
919-547-2661

Dawn Gouge
University of Arizona
37860 West Smith-Enke Rd.
Maricopa, AZ 85238
602-418-5202
dhgouge@ag.arizona.edu

Ken Grace
University of Hawaii
PEPS Dept.
3050 Maile Way
Honolulu, HI 96822
808-956-6737
kennethg@hawaii.edu

Fudd Graham
Auburn University
301 Funchess Hall
Auburn, AL 36849-5413
334-844-2563
grahalc@auburn.edu

Theodore Granovsky
Granovsky Assoc.
1720 Barak
Bryan, TX 77802
979-691-2629
tag@granovsky.com

Thomas Green
IPM Inst. of North America
4510 Regent St.
Madison, WI 53705
608-232-1410
ipmworks@ipminstitute.org

Frank Guillot
USDA/ARS/FST
1100 Robert E. Lee Blvd.
New Orleans, LA 70124
504-286-4429
frank.guillot@ars.usda.gov

Keith Haas
Central Life Sciences
12111 Ford Rd.
Dallas, TX 75234
972-888-8675
khaas@central.com

Martyn Hafley
FMC Corp.
2990 Marlow Lane
Richardson, TX 75082
972-632-6522
brian.mount@fmc.com

Laurel Hansen
Spokane Falls Community College
Biology Department
3410 Fort Wright Dr.
Spokane, WA 99224
509-533-3666
laurelh@spokanefalls.edu

Brad Harbison
PCT Magazine
4020 Kinross Lakes Pkwy
Richfield, OH 44286
330-523-5323
bharbison@gie.net

Paul Hardy
Orkin
170 Piedmont Rd. NE
Atlanta, GA 30324
404-888-2617
phardy@rollins.com

Ron Harrison
Orkin
2552 NE Expressway
Atlanta, GA 30345
404-877-4603
rharrison@rollins.com

Bob Hartley
Truly Nolen of America, Inc.
3636 E. Speedway Blvd.
Tucson, AZ 85716
520-322-4060
rw.hartley@trulymail.net

Michael I. Haverty
University of CA-Berkeley
941 Carol Lane
Lafayette, CA 94549
925-451-7234
mhaverty@berkeley.edu

Heidi Hawkins
5 Star Termite & Pest Control
1002 S. Pantano Rd.
Tucson, AZ 85710
520-886-0045
shelby5664@msn.com

Shelby Hawkins
5 Star Termite & Pest Control
1002 S. Pantano Rd.
Tucson, AZ 85710
520-886-0045
shelby5664@msn.com

Justin Hedlund
The Steritech Group
115 Barney St.
East Providence, RI 02916
justin.hedlund@steritech.com

Bob Hickman
BASF Corp.
1220 Manchester Rd.
Maitland, FL 32751
407-257-9722
robert.hickman@basf.com

Akio Higo
KT Consulting
4-4-704 Matsuhama-cho
Nishinomiya, Hyogo JAPAN 663-8101
81-798-65-5705
akiohigomgk@aol.com

Nancy Hinkle
University of Georgia
Dept. of Entomology
Athens, GA 30602
706-583-8043
nhinkle@uga.edu

Ronnie Holder
BASF Specialty Products
935 Eldridge # 614
Sugar Land, TX 77478
713-294-7628
ronald.holder@basf.com

Joe Hope
Bayer Environmental Science
1 T.W. Alexander Dr.
Research Triangle Park, NC 27709
919-549-2513
joe.hope@bayercropscience.com

John Hopkins
University of Ark. Cooperative Extension
P.O. Box 391
Little Rock, AR 72203
501-671-2217
jhopkins@uaex.edu

Patricia Hottel
McCloud Services
2500 W. Higgins Rd., St. 850
Hoffman Estates, IL 60169
847-585-0654
mcteknical@aol.com

Richard Houseman
University of Missouri
1-31 Agriculture Bldg.
Columbia, MO 65211
573-882-7181
housemanr@missouri.edu

Xing Ping Hu
Auburn University
203 Extension Hall, AU
Auburn, AL 36849
334-844-6392
huxingp@auburn.edu

Janet Hurley
Texas AgriLife Extension
17360 Coit Rd
Dallas, TX 75252
972-952-9213
ja-hurley@tamu.edu

Darrell Hutto
Horizon Prof. & Consulting Services
20714 Harvest Hill
Houston, TX 77073
281-821-4440
hpcservices@peoplepc.com

Reid Ipser
Waterbury Companies
129 Calhoun St.
Independence, LA 70454
985-878-6751
ripser@watco.com

Steve Jacobs
Penn State University
Dept. of Entomology
513 ASI Bldg.
State University Park, PA 16802
814-863-3963
jacobs@psu.edu

Laura Jesse
Iowa State University
327 Bessey Hall
Ames, IA 50011
515-294-5374
ljesse@iastate.edu

Susan Jones
Ohio State University
Dept. of Entomology
1991 Kenny Rd.
Columbus, OH 43210
614-292-2752
jones.1800@osu.edu

Kyle Jordan
Whitmire Micro-Gen
1305 Weatherstone Way NE
Atlanta, GA 30324
404-323-2756

Dennis Justice
The Steritech Group
103 Hawkesbury Rd.
Simpsonville, SC 29681
dennis.justice@steritech.com

Shripat Kamble
University of Nebraska
Dept. of Entomology
Lincoln, NE 68583
402-472-6857
skamble1@unl.edu

Brad Kard
Oklahoma State University
127 NRC
Stillwater, OK 74078
405-744-2142
kard@okstate.edu

Chris Keefer
Texas A&M University
2143 TAMU
College Station, TX 77843-2143
979-845-5855
tckeefer@ag.tamu.edu

Ken Kendall
Ensystex, Inc.
2713 Breezewood Ave., 2nd floor
Fayetteville, NC 28303
910-485-5720 ext. 5206
ken@ensystex.com

Bill Kern
University of Florida
3205 College Ave.
Davie, FL 33314
954-577-6329
whk@ufl.edu

Susan King
University of Delaware
Dept. of Entomology & Wildlife Ecology
Newark, DE 19716
302-831-8886
swhitney@udel.edu

Janet Kintz-Early
Nisus Corp.
100 Nisus Drive
Rockford, TN 37853
865-577-6119
janete@nisuscorp.com

John Klotz
University of CA-Riverside
Dept. of Entomology
Riverside, CA 92521
951-827-3898
john.klotz@ucr.edu

Bill Kolbe
BASF Corp.
9 Bowers Place
Denville, NJ 07834
973-784-3760
william.kolbe@basf.com

Robert Kopanic
S.C. Johnson & Son, Inc.
1525 Howe Street
Racine, WI 53403
262-260-6073
rjkopani@scj.com

Deborah Koufas
Bayer Environmental Science
981 NC Hwy 42E
Clayton, NC 27527
919-524-4645
deborah.koufas@bayercropscience.com

Marc Lame
Indiana University
1315 E. Tenth St.
Bloomington, IN 47405
mlame@indiana.edu

Michael Lawton
Western Exterminator Co.
305 N. Crescent Way
Anaheim, CA 92801
714-517-9000
mlawton@west-ext.com

Blake Layton
Mississippi State University
100 Twelue Lane
Mississippi State, MS 39762
662-325-2085

Albert Lee
Louisiana State University
404 Life Sciences Bldg.
Baton Rouge, LA 70803
225-578-7149
leeahy@gmail.com

Donald Lewis
Iowa State University
104 Insectary
Ames, IA 50011
515-294-1101
drlewis@iastate.edu

Dangsheng Liang
Apex Bait Technologies, Inc.
309 Laurelwood Rd., St. 18-2
Santa Clara, CA 95054
408-969-0088

Catherine Long
Syngenta Prof. Products
7145 58th Ave.
Vero Beach, FL 32967
772-567-5218
catherine.long@syngenta.com

Clark Lovelady
Syngenta Prof. Products
7145 58th Ave.
Vero Beach, FL 32967
772-567-5218 ext. 116
clark.lovelady@syngenta.com

Charles Luper
Oklahoma State University
127 NRC
Stillwater, OK 74078
405-744-5808
charles.luper@okstate.edu

Lixin Mao
Louisiana State University Ag. Center
404 Life Sciences Bldg.
Baton Rouge, LA 70803
225-578-7151
lmao@agcenter.lsu.edu

Bill McClellan
DuPont Corp.
3306 Cheveus
Glen Mills, PA 19342
302-690-6103
wdmconsulting@aol.com

Phil McNally
Bayer Environmental Science
204 Bethabara
Cary, NC 27513
949-887-6463
phil.mcnally@bayercropscience.com

Frank Meek
Orkin
2170 Piedmont Rd. NE
Atlanta, GA 30324
404-888-2898
fmeek@rollins.com

Anil Menon
BASF Corp.
26 Davis Drive
Research Triangle Park, NC 27709
919-547-2680
anil.menon@basf.com

Mike Merchant
Texas AgriLife Extension
17360 Coit Rd
Dallas, TX 75252
972-952-9204
m-merchant@tamu.edu

Matthew Messenger
Dow AgroSciences
5364 Broadway St.
Indianapolis, IN 46220
317-242-8080
mmessenger@dow.com

Jason Meyers
Texas A&M University
2143 TAMU
College Station, TX 77843-2143
979-845-5855
jmmeyers@tamu.edu

Raymond Meyers
RJM Contracting
630 Brookfield Loop
Lake Mary, FL 32746
407-620-0011
vespidae@msn.com

Dini Miller
Virginia Tech
216A Price Hall
Blacksburg, VA 24061
540-231-4918
dinim@vt.edu

Erin Monteagudo
Western Industries, North
P.O. Box 367
Parsippany, NJ 07054-0367
973-515-0100
emonteagudo@westernpest.com

Alan Morgan
Louisiana State University Ag. Center
404 Life Sciences Bldg.
Baton Rouge, LA 70803
225-578-2180
amorgan@agcenter.lsu.edu

Tim Myles
University of Toronto/ City of Guelph
59 Carden Street, City Hall
Guelph, ON, Canada N1H3A1
519-836-5615
tim.myles@guelph.ca

Dave Naffziger
Whitmire Micro-Gen Res. Lab
3568 Tree Court Industrial Blvd.
St. Louis, MO 63122
636-861-4237
david.naffziger@wmmg.com

Laura Nelson
Texas A&M University
2143 TAMU
College Station, TX 77843-2143
979-845-5855

Phil Nichols
Middleton Lawn & Pest Control
1736 33rd Street
Orlando, FL 32839
407-948-1908
pnichols@middletonpest.com

Tom Nishimura
BASF Corp.
6502 Montana Ln.
Vancouver, WA 98661
503-887-7273
thomas.nishimura@basf.com

Monty Northern
Granovsky Assoc.
1720 Barak
Bryan, TX 77802
979-691-2629
monty@granovsky.com

Barbara Ogg
University of Nebraska-Lincoln
444 Cherrycreek Rd., St. A
Lincoln, NE 68582
402-441-7180
bogg1@unl.edu

Clyde Ogg
University of Nebraska-Lincoln
101 Natural Resources Hall
Lincoln, NE 68583-0820
402-472-1632
cogg@unl.edu

John Paige, III
Bayer Environmental Science
328 Indian Lilac Rd.
Vero Beach, FL 32963
772-633-8883
john.paige@bayercropscience.com

Hank Palmer
The Steritech Group
7600 Little Ave.
Charlotte, NC 28226
hank.palmer@steritech.com

Venkat Pedibhotla
BASF Corp.
26 Davis Dr.
Research Triangle Park, NC 27709
919-547-2093

Joel Perez-Mendoza
Schendel Pest Services
1824 S. Kansas Ave.
Topeka, KS 66612
785-232-9357
joel.mendoza@pestzero.com

Rudy Plarre
Federal Inst. for Materials Research & Testing
Unter den Eichen 87
Berlin, Germany 12205
ruediger.plarre@bam.de

Mike Potter
University of Kentucky
S-225 Agricultural Science Bldg., Bldg. N
Lexington, KY 40546-0091
859-257-2398
mpotter@uky.edu

Janis Reed
ABC Services
9519 IH 35
North Austin, TX 78753
512-837-9500
jreed@abcpest.com

Byron Reid
Bayer Environmental Science
2 T.W. Alexander Drive
Research Triangle Park, NC 27709
919-491-7531

Donald Reierson
University of California
Dept. of Entomology
Riverside, CA 92521
951-827-3609
donald.reierson@ucr.edu

Matthew Remmen
Western Industries, North
P.O. Box 367
Parsippany, NJ 07054-0367
973-515-0100
mremmen@westernpest.com

Dina Richman
FMC Corp.
1735 Market Street
Philadelphia, PA 19103
215-299-6959
dina.richman@fmc.com

Claudia Riegel
City of New Orleans Mosquito & Termite Control
6601 Stars & Stripes Blvd
New Orleans, LA 70126
504-415-7068
criegel@cityofno.com

Dennis Ring
Louisiana State University Ag. Center
Dept. of Entomology
404 Life Sciences Bldg.
Baton Rouge, LA 70803
225-978-3881
dring@agcenter.lsu.edu

Tom Rogers
Orkin
242 Williams Cir.
Flowood, MS 39232
trogers@orkin.com

Alvaro Romero
University of Kentucky
S-225 Agricultural Science Bldg., Bldg. N
Lexington, KY 40546-0091
859-242-0632
alvromero@uky.edu

Jack Root
North & Root Consulting
799 Rd. 2900
Aztec, NM 87410
505-334-1568
jack@northandroot.com

El Ray Roper
Syngenta Prof. Products
2911 N. 175
East Provo, UT 84604
707-208-5173
elrayroper@syngenta.com

Brittany Russ
Clemson University
Dept. ESPS
114 Long Hall,
Clemson, SC 29634-0315
864-656-3111
brittar@clemson.edu

Raj Saran
MGK
8810 10th Ave. North
Minneapolis, MN 55427
763-544-0341
raj.saran@mgk.com

Jim Sargent
Copesan
W175 N5711 Technology Dr.
Menomonee Falls, WI 53051
262-783-6261
sarge@copesan.com

Coby Schal
North Carolina State University
Dept. of Entomology
Raleigh, NC 27695
919-515-1821
coby_schal@ncsu.edu

Mike Scharf
University of Florida
Bldg. 970 Natural Area Dr.
Gainesville, FL 32611
352-392-1901
mescharf@ufl.edu

Rudi Scheffrahn
University of Florida
3205 College Ave.
Fort Lauderdale, FL 33314
954-577-6312
rhsc@ufl.edu

Clay Scherer
DuPont Corp.
4417 Lancaster Pike/Centre Rd CRP 1N40
Wilmington, DE 19880-0705
302-218-2451
clay.w.scherer@usa.dupont.com

Joe Schuh
BASF Corp.
26 Davis Drive
Research Triangle Park, NC 27709
919-547-2676
joseph.schuh@basf.com

Chris Scocco
University of Georgia
1109 Experiment St.
Griffin, GA 30223
770-228-7288
cscocco@griffin.uga.edu

Kevin Shelton
Oklahoma State University
127 NRC
Stillwater, OK 74078
405-744-1060
kevin.shelton@okstate.edu

Steve Sims
Whitmire Micro-Gen Res. Lab
3568 Tree Court Industrial Blvd.
St. Louis, MO 63122
636-861-4264
steve.sims@wmmg.com

Kellie Smith
Arizona Structural Pest Control Com.
9535 E. Doubletree Ranch Rd.
Scottsdale, AZ 85258
602-255-3664
ksmith@sb.state.az.us

Michelle Smith
Dow AgroSciences
9330 Zionsville Rd. 308/3A
Indianapolis, IN 46268
317-337-4502
mssmith@dow.com

Todd Smith
Snell Scientifics/UGA
188 Vega Rd.
Meansville, GA 30256
770-358-4591
todd@snellsci.com

Eric Snell
Snell Scientifics/UGA
188 Vega Rd.
Meansville, GA 30256
770-358-4591
esnell@snellsci.com

Rami Soufi
The Scotts Co.
14111 Soottslawn Rd.
Marysville, OH 43041
937-644-7041
rami.soufi@scotts.com

Nick Spero
ICR, Inc.
1330 Dillon Heights Ave.
Baltimore, MD 21228
410-747-4500
NSpero@icrlab.com

Forrest St. Aubin
SummaCon Consultants
12835 Pembroke Dr
Leawood, KS 66209
913-345-2114
forrest@saintaubinbce.com

Patrick Standley
Snell Scientifics/UGA
188 Vega Rd.
Meansville, GA 30256
770-358-4591
patrick@snellsci.com

Rachel Strecker
Louisiana State University
404 Life Sciences Bldg.
Baton Rouge, LA 70803
225-578-7149
rsreecker@agcentr.edu

Fred Strickland
Terminix Int'l
860 Ridge Lake Blvd.
Memphis, TN 38120
901-597-1279
fsrtickland@terminix.com

Nan-Yao Su
University of Florida
3205 College Ave.
Davie, FL 33314
954-577-6339
nysu@ufl.edu

Dan Suiter
University of Georgia
1109 Experiment St.
Griffin, GA 30223
770-233-6114
dsuiter@griffin.uga.edu

Jian-Zhong Sun
Mississippi State University
P.O. Box 193
Poplarville, MS 39470
601-403-8772
js841@msstate.edu

Allen Szalanski
University of Arkansas
Dept. of Entomology
319 Agri. Bldg.
Fayetteville, AR 72701
479-575-4342
aszalan@uark.edu

Matt Tarver
University of Florida
Bldg. 970 Natural Area Dr.
Gainesville, FL 32611
352-392-1901 ext. 200
tarverm@ufl.edu

Andrew Tebeau
Clemson University
Dept. ESPS
114 Long Hall
Clemson, SC 29634-0315
864-656-3137
atebeau@clemson.edu

Pete Teel
Texas A&M University
2475 TAMU
College Station, TX 77843-2475
979-845-3253
pteel@ag.tamu.edu

Ellen Thoms
Dow AgroSciences
7257 NW 4th Blvd., #20
Gainesville, FL 32607
352-332-5682
emthoms@dow.com

Jeff Tucker
Entomology Associates
P.O. Box 70375
Houston, TX 77270
713-681-9004
jtucker@birch.net

Karen Vail
University of Tennessee
2431 Joe Johnson Dr.
205 Ellington Plant Science Bldg.
Knoxville, TN 37996-4560
865-971-8800
kvail@utk.edu

Tom Vandenberg
XT-2000
6328 Riverdale
San Diego, CA 92120
866-870-8485
tomv60@sbcglobal.net

Rick Vetter
University of CA-Riverside
Entomology Dept.
Riverside, CA 92521
951-827-5805
rick.vetter@ucr.edu

John Warner
University of Florida
6681 Via Regina
Boca Raton, FL 33433
561-477-8664
whitefootedant@gmail.com

Carol Wyatt-Evens
Syngenta Prof. Products
7145 58th Ave.
Vero Beach, FL 32967
772-567-5218
carol.wyattevens@syngenta.com

Cole Younger
Stillmeadow, Inc.
12852 Park One Drive
Sugar Land, TX 77478
281-240-8828
cyounger@stillmeadow.com

Jing Zhai
Eurofins-Agrisearch Americas
9 Jennifer Ln.
Campbell Hall, NY 10916
845-496-3017
jing.zhai@eurofins-agrisearch.com

Pat Zungoli
Clemson University
Dept. ESPS
114 Long Hall
Clemson, SC 29634-0315
864-656-3137
pzngl@clemson.edu