

A photograph of a desert landscape featuring several saguaro cacti. A single red cockroach is perched on one of the cacti in the center. In the background, there are mountains under a clear blue sky.

Proceedings of the 2004 National Conference on Urban Entomology

May 20-22, 2004

Hyatt Regency Phoenix
Phoenix, Arizona

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Regency Ballroom C & D

THE MALLIS MEMORIAL AWARD LECTURE: URBAN ENTOMOLOGY – THE NEXT GENERATION

Roger E. Gold

Professor and Endowed Chair, Department of Entomology
Texas A&M University

URBAN ENTOMOLOGY- The Next Generation

Roger E. Gold
Professor & Endowed Chair
Center for Urban & Structural Entomology
Department of Entomology
Texas A&M University



INTRODUCTION

- I AM CERTAINLY HONORED TO BE PRESENTING THIS LECTURE
- AS WITH MANY HERE TODAY MY CAREER STARTED IN EXTENSION
- I DEVELOPED AN INTEREST IN URBAN INSECT CONTROL THROUGH ENCOURAGEMENT OF COLLEAGUES

INTRODUCTION

- I COULD HAVE NEVER ANTICIPATE THE COURSE THAT MY PROFESSIONAL CAREER HAS TAKEN, OR THE CHALLENGES THAT HAVE OCCURRED OVER THE PAST 30 YEARS

INTRODUCTION

- I AM PARTICULARLY HONORED AS I REVIEW THE NAMES OF THOSE THAT HAVE RECEIVED THIS AWARD IN THE PAST.

Distinguished Achievement Award Recipients

- Walter Ebeling
- James Grayson
- John Osmun
- Eugene Wood
- Francis Lechleitner
- Charles Wright
- Roger Aker
- Harry Moore
- Mary Ross
- Don Cochran
- Gary Bennett
- Michael Rust

INTRODUCTION

- I HAVE NOW HAD THE OPPORTUNITY OF MEETING MANY OF THE EARLY URBAN ENTOMOLOGISTS, AND I APPRECIATE THE PATHS THAT THEY LAID OUT TO MAKE MY WAY THAT MUCH EASIER.

PERSONAL PERSPECTIVE ON THE NEXT GENERATION

- FOR THOSE HERE WHO HAVE CHILDREN & GRANDCHILDREN, YOU WOULD SHARE WITH ME THE EXCITEMENT AND PRIDE THAT COMES WITH THEIR SUCCESS, AND THE ANGUISH AND WORRIES THAT COMES WHEN THEY STUGGLE

PERSONAL PERSPECTIVE GRADUATE STUDENTS

- THEY ALSO ARE A PART OF MY FAMILY.

GRADUATE STUDENTS: M.S.

- Richard Clopton
- Kable Bo Davis
- Kimberly Engler
- Marc Fisher
- Barry Furman
- Elizabeth Johnson
- Indira Kuriachan
- Clyde Ogg
- Hemasiri Rajapakse
- John Rauscher
- Damon Shodrock
- Rebecca Vahabzadeh
- Art Vance
- Troy Waite
- Richard Warriner
- Philip Whiting

Graduate Students: Ph.D.

- Dr. James Ballard
- Dr. Jerry Cook
- Dr. Tamara Cook
- Dr. Bart Foster
- Dr. Richard Houseman
- Dr. Harry N. Howell Jr.
- Dr. Tom Macom
- Dr. Tim Miller

Post-Doctorates

- Dr. Richard Clopton
- Dr. Jerry Cook
- Dr. Tamara Cook
- Dr. Gerald Harris
- Dr. Barry Pawson

Present Graduate Students

- Lucille Benavides M.S.
- Molly Bush M.S.
- Bryan Heintschel M.S.
- Anne Narayanan M.S.
- Barry Furman Ph.D.
- Grady Glenn Ph.D.

PROFESSIONAL STAFF

- RECOGNIZE THE CONTRIBUTIONS OF THE ADMINISTRATIVE STAFF, SCIENTISTS, TECHNICIANS, & WORKERS.

URBAN ENTOMOLOGY

- MANY DEFINITIONS
- DIFFERENT PERSPECTIVES
- **DEBATE IS A PART OF SCIENCE**

URBAN ENTOMOLOGY TAMU

- THE INTEGRATED MANAGEMENT OF INSECTS ASSOCIATED WITH HUMANS AND THEIR COMPANION ANIMALS (Hatch Project).

URBAN ENTOMOLOGY

- WHERE WE LIVE
- WHERE WE WORK
- WHERE OUR FOOD IS:
 - STORED
 - PROCESSED
 - MARKETED
 - CONSUMED
- WHERE WE WORSHIP
- **WHERE WE REST AND HAVE RECREATION**

URBAN ENTOMOLOGY

- IT EMPHASIZES ALL ASPECTS OF OUR LIVES AND EXISTENCE
- **WE KNOW FROM THE CENSUS THAT THE MAJORITY OF AMERICANS LIVE IN AN URBAN SETTING (90%) KNOWN AS A POPULATION CENTER**

URBAN ENTOMOLOGY

- WE KNOW THAT PEOPLE LIVING IN RURAL ENVIRONMENTS ALSO HAVE STRUCTURAL AND STORED PRODUCT PESTS
- PERHAPS “URBAN” IS TOO RESTRICTIVE TO OUR TRUE MISSION OF PROTECTING THE HEALTH AND WELL BEING OF ALL OF OUR CLIENTS
- **OTHER TERMS:**
URBAN/STRUCTURAL/INDUSTRIAL

SO WHO ARE THE NEW URBAN ENTOMOLOGISTS?

URBAN SPECIALIST

- STUDENTS EMPHASIZING URBAN PERSPECTIVES

URBAN SPECIALIST

- STUDENTS EMPHASIZING URBAN PERSPECTIVES
- LARGE FORMAL PROGRAMS IN URBAN ENTOMOLOGY
- PLACEMENT OF TRAINED PERSONEL
- **FUTURE IS BRIGHT**

WHAT IS EXPECTED OF THE NEXT GENERATION OF URBAN ENTOMOLOGISTS

- EXCELLENT EDUCATION/TRAINING
- PRACTICAL EXPERIENCE
- EMPATHY FOR THE PUBLIC/INDUSTRY
- INTEGRITY & INTELLECTUAL HONESTY
- **RESOURCEFUL**
- **ABILITY TO ADAPT**

WHAT ARE SOME OF THE CHALLENGES THAT WE WILL FACE IN THE FUTURE

- ADJUSTING TO CHANGE
- INFORMATION OVERLOAD
 - (Internet +/-)
- LEGISLATIVE MANDATES
- ENVIRONMENTAL CONCERNS
- PUBLIC HEALTH ISSUES
- A GLOBAL ECONOMY (EXOTIC SPECIES)

UNIQUE SITUATIONS URBAN

- IN AGRICULTURE MANY ACRES OWNED BY A SINGLE FAMILY
- IN URBAN ENVIRONMENTS, MANY FAMILIES PER ACRE
- CONTROL MEASURES HAVE WIDE REACHING CONSEQUENCES IN URBAN SITUATIONS
- CULTURAL BACKGROUND DEFINE PESTS (MOBILE SOCIETY)

URBAN UNIQUE SITUATIONS

- INTEGRATED PEST MANAGEMENT

URBAN UNIQUE SITUATIONS

- INTEGRATED PEST MANAGEMENT
 - MANDATED (LOCAL/STATE/FEDERAL)
 - BASED ON THRESHOLDS:
 - DETECTION
 - ECONOMIC
 - ECONOMIC INJURY LEVELS
 - EQUILIBRIUM FOR MEAN POPULATIONS
 - AESTHETIC THRESHOLD
 - GENERALLY UNDEFINED TOLERANCES

URBAN ENVIRONMENTS

- HUMAN INTENSE

URBAN ENVIRONMENTS

- HUMAN INTENSE
- COMPLEX ECOSYSTEMS (DIVERSITY)
- ENVIRONMENTAL MANIPULATIONS
 - (WEATHER: INSIDE/OUT)
- GATHERING & HORDING SOCIETIES
- INDIVIDUAL VS. COMMUNITY RIGHTS
- RECYCLING (Formosan Termites)

PREPARATION OF THE NEXT GENERATION

- TEACHING
- RESEARCH
- SERVICE

TEACHING URBAN ENTOMOLOGY

- PHILOSOPHY OF PEST MANAGEMENT
- CLASSIFICATION SYSTEM OF INSECTS
- SIGHT RECOGNITION OF INSECTS
- DAMAGE RECOGNITION
- GENERAL BIOLOGY
- INTEGRATED MANAGEMENT OF POPULATIONS
- **TO ACCESS “QUALITY SOURCES OF INFORMATION”**

RESEARCH

- **ETHICS & HONORABLE BEHAVIOR**

RESEARCH

- ETHICS & HONORABLE BEHAVIOR
- SCIENTIFIC METHOD
- BASED ON A HYPOTHESIS
- OBJECTIVE EVALUATION OF DATA
- UNBIASED REPORTING OF RESULTS
- FAIR EVALUATION OF WORK OF OTHERS
- **RESULTS MUST MAKE BIOLOGICAL SENSE**

SERVICE

- DESIRE TO HELP OTHERS
- COURAGE TO ANSWER QUESTIONS
- ACCURATE INFORMATION
- RECOGNITION OF “DO NOT KNOW”
- BE WILLING TO LEARN AND GROW
- KNOW WHERE TO GET HELP
- **DEVELOP COMMUNICATION SKILLS**

CONCLUSIONS

- THE FUTURE IS IN ABLE HANDS
- THE NEXT GENERATION IS:
 - INTELLECTUALLY GIFTED
 - WELL TRAINED
 - TECHNOLOGICALLY SUPERIOR
 - MOTIVATED TO SUCCEED
 - **MUST BE CHALLENGED & REWARDED**

DESERT TERMITE DIVERSITY

Regency Ballroom C & D

**In honor of William L. (Bill) Nutting,
Pioneer of Desert Termite Research**

Organizer and Moderator

Brad Kard

Oklahoma State University, Stillwater, OK

BILL NUTTING: STUDENT, TEACHER, MENTOR, PIONEER

Brad Kard

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I first met the honorable Bill Nutting at the Entomological Society of America Annual Meeting in Boston, MA, in 1987. He was introduced to me by Susan Jones, previously one of his many esteemed graduate students. What struck me most about Dr. Nutting was his enthusiasm and interest in what other scientists were doing, and his tendency to articulate encouraging and complimentary comments about the accomplishments of others. He did not talk about his own extensive scientific achievements, but emphasized the benefits of research conducted by colleagues. He was clearly revered and respected by those around him, but seemed to not notice. He wanted to hear about what others were studying and thinking about. His wife accompanied him, and also commanded the respect of those around her. I was greatly impressed by this accomplished and thoughtful man. Meeting him was a privilege I will always value. I did not consider that in less than five years he would depart from us.

Bill's wife, Ruth, and his former graduate student and colleague, Mike Haverty, published a short celebration of his life in the Winter 2002 issue of American Entomologist 48(4): 245-247. A condensed version follows.

WILLIAM L. NUTTING (1922-1992).
Ruth D. Nutting, Michael I. Haverty, and Brad Kard

Bill was born in Pepperell, MA, on July 26, 1922. As a boy he showed intense interest and aptitude for things biological, and was encouraged by his parents and grandparents. His early collections of insects, plants, and animals were extensive. At the suggestion of his grandmother that he document his endeavors, from age 10 he kept a daily diary of his scientific activities, giving us first hand insight into his early life and pursuits. He did well in school and entered Harvard College in 1940. With the United States' declaration of war during his second year, he accelerated his studies, graduating in 1943 with a BA in biology.

Following graduation, he immediately enlisted in the Navy and completed Officer Candidate School, receiving a commission as an Ensign. Following service in the Pacific Theater, Lieutenant Junior Grade Nutting was released from active duty and enrolled in Harvard under Professor F. M. Carpenter, where he studied the comparative morphology of the orthopteroid heart. His drawings of the cockroach heart appear in entomology texts today.

An excellent scientific artist, he drew many illustrations for the publications of L. R. Cleveland, a parasitologist. These illustrations depicted the relationship between the reproductive cycle of gut protozoa found in the primitive, wood-feeding roach, *Cryptocercus*, and molting of this host insect. He continued to work with Cleveland as a post-doctoral fellow.

As graduate students, Bill and Floyd Werner made insect collecting trips to Cuba, Mexico, and the southwestern United States. Subsequently, he accepted a position at the University of Arizona in Tucson in September 1955. He arrived with his wife, Ruth, and two young sons, not suspecting their stay would last a lifetime.

Bill worked on control of the khapra beetle, an East Indian grain pest, and developed and taught insect morphology, physiology, and behavior, keeping these popular courses up-to-date and relevant to current discoveries from year-to-year. He conducted field research that led to several summers teaching field zoology at Harvard and Boston University. Under his direction, 17 students earned MS degrees, and 11 completed their Ph.Ds.

By the early 1960s, Bill's research focused on the behavior and ecology of termites, investigating the influence of weather and temporal aspects on termite swarming. He worked on the Santa Rita Range Reserve, south of Tucson, studying foraging and demographics of termites. He put his practical knowledge to use by providing teaching sessions for Arizona pest control operators. He also

advised the public on identification and control of all types of wood-destroying insects.

Although he worked most often in Arizona, in 1964, he investigated the biology of Mexican termites in Jalisco. In 1980, he worked in Nairobi, Kenya, as the project leader of the Grassland Termites Research Programme for the International Centre for Insect Physiology and Ecology. The Nuttings traveled the world, collecting termites wherever they went. This led to the extensive termite collection currently housed at the University of Arizona.

Bill was sought out by students and colleagues for his extensive knowledge of the literature of insect morphology, physiology, and behavior, especially for termites and orthopteroids. He kept a file of carefully chosen references, and published numerous research papers and several chapters in textbooks. He was a member of many honorary and scientific societies, and served as the President of the North American Section of the International Union for the Study of Social Insects in 1983.

He retired from teaching in 1983, but two years later returned to the University of Arizona as Acting Head of the Department of Entomology. He continued his research on the biogeography of termites even when terminally ill with cancer. Bill died on March 8, 1992.

He is remembered with deep respect by those who knew him and of his work.

***HETEROTERMES AUREUS*, THE DESERT SUBTERRANEAN TERMITE: RESEARCH OVERVIEW**

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Heterotermes aureus (Snyder), the desert subterranean termite, is the most common of the subterranean termite species in the Sonoran Desert below ~1,220 m. It occurs in the desert areas of southwestern Arizona; southeastern California; and Sonora, Sinaloa, and Baja California in Mexico (Pickens and Light 1934, Jones and Nutting 1989). Its tolerance of high temperatures and desiccation (Collins 1969, Collins et al. 1973) enables it to occupy these desert regions. The distribution of *H. aureus* apparently is limited by low rather than high temperatures (Haverty and Nutting 1976).

The role of *H. aureus* in the detritus cycle has been extensively studied with regard to soil movement and alteration (Nutting et al. 1987), wood preferences (Haverty and Nutting 1975a, 1975b), and rates of dead wood production and consumption (Haverty and Nutting 1975c). The methodology of using toilet-paper

rolls to study termite foraging populations was initiated with this species (La Fage et al. 1973, Haverty et al. 1976). Various aspects of *H. aureus* foraging ecology have been described including abiotic influences (Haverty et al. 1974, Jones et al. 1987), seasonal activity (Haverty et al. 1974, Jones et al. 1987), territory size (Haverty et al. 1975, Jones 1990a), colony size (Jones 1990b), interspecific competition (Jones and Trosset 1991), and intracolony aggression (Jones 1993).

H. aureus is an economically important pest that damages wooden structures, poles, and posts (Pickens and Light 1934). Efficacy of soil termiticides is evaluated against this species, which predominates in USDA Forest Service field plots at the Santa Rita Experimental Range in southern Arizona (Kard et al. 1989, Wegner et al. 2002). On-going efforts to control this pest are important.

This presentation will provide an overview of laboratory and field research on *H. aureus*.

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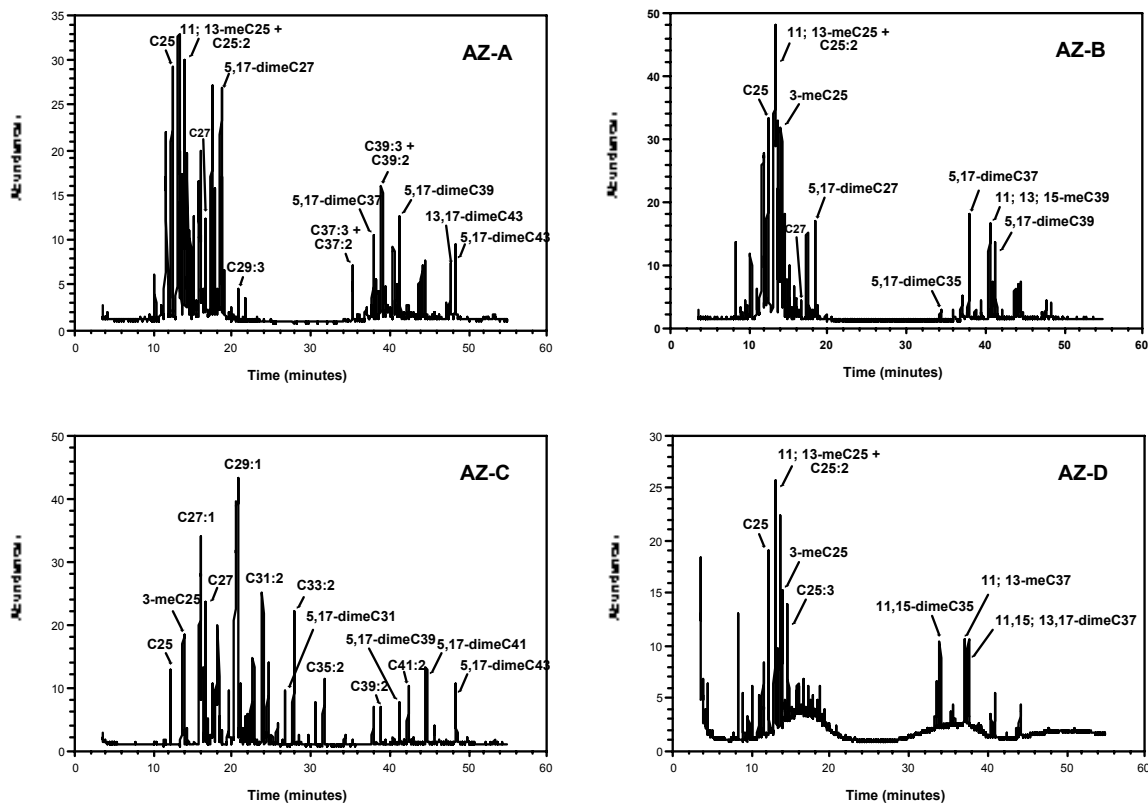
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***RETICULITERMES* SPECIES IN ARIZONA**

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Biogeographical information on *Reticulitermes* in the U.S. suggests the only species found in Arizona is *R. tibialis* Banks. Much of this information was developed early in the last century and relies heavily on the original descriptions by Banks and Snyder and subsequent synonymies by Snyder. The Entomology

Museum at the University of Arizona has an extensive collection of *Reticulitermes* that was used to describe the distribution of *R. tibialis* relative to *Heterotermes aureus* (Snyder), an ecological equivalent occurring in the Sonoran Desert. *Reticulitermes* occurs naturally throughout Arizona with the exception of much of the Sonoran and Colorado Deserts. We have made additional collections of *Reticulitermes* from Arizona and neighboring states to characterize their cuticular hydrocarbons for taxonomic purposes. For *Reticulitermes* these mixtures appear to be more informative than morphological characters of soldiers. Cuticular hydrocarbon mixtures of *Reticulitermes* samples from disparate locations in Arizona provided unexpected results. Rather than only one taxon being found, we identified four taxa based on their cuticular hydrocarbon mixtures. We labeled them AZ-A, AZ-B, AZ-C, and AZ-D based on the order in which they were discovered.



The predominant hydrocarbons in AZ-A have 25 and 27 carbons in the parent chain, including 5,17-dimeC27. The late-eluting compounds are comprised primarily of dienes, trienes, a homologous series of internally branched mono- and dimethylalkanes, and 5,17-dimethylalkanes. AZ-B differs from AZ-A by lacking the late-eluting dienes and trienes and produces smaller amounts of hydrocarbons with 27 carbons in the parent chain. AZ-C is very different from all of the other western *Reticulitermes*. The cuticular hydrocarbons in AZ-C are composed primarily of olefins; C29:1 is the most abundant, and with C27:1,

C31:2 and C33:2 predominates the hydrocarbon mixture. This phenotype also has a homologous series of 5,17-dimethylalkanes from C27 to C43. AZ-D is distinguished by the absence of any 5-methylalkanes, 5,17-dimethylalkanes, or late-eluting dienes or trienes. The hydrocarbon mixture of AZ-D most closely resembles that of *R. hesperus* from northern California.

AZ-A is not common; the few samples we have collected are all at the higher elevations 6,000 to 7,000 feet on the Mogollon Rim. AZ-B is probably the most common and can be found throughout the state from Fairbank (ca. 4,000 feet) to Jacob Lake (ca. 8,000 feet). This phenotype is also found in southern Nevada and Utah. AZ-C is sympatric with AZ-B over most of the distribution of the latter, but is allopatric in southern Arizona. AZ-C occurs at high elevations on the desert islands of southeastern Arizona, such as the Santa Catalina, Santa Rita, Chiricahua, and Pinaleno Mountains, whereas AZ-B occurs at lower elevations, usually associated with a riparian area.

Soldier defense secretion mixtures have been characterized for samples of AZ-A, AZ-B and AZ-C. Soldiers of AZ-A have mostly geranyl linalool (82.4%) and γ -cadinene (16.8%) in their defense secretions. AZ-B has a similar terpene profile, though quantities were variable. AZ-B generally has more γ -cadinenal (0.5 to 13.2%) than AZ-A (0-1.3%), and the percentage of geranyl linalool ranged from 26.4% to 78.3% (mean = 64.4%), γ -cadinene from 9.7% to 66.7% (mean = 23.1%). Soldier defense secretions from AZ-C show evidence of geographic differences. Samples from the Mogollon (Interior) biogeographic province, from Prescott to Springerville, had soldier defense secretions consisting mainly of myrcene (1.3-20.3%), Z- and E-ocimenes (0-19.8%), β -bisabolene (17.8-57.3%), γ -cadinene (1.8-40.5%), and geranyl linalool (0-50.4%). We summarized these samples as one group, AZ-C(I), though they were quite variable. There was much less variability in SDS profiles from samples collected in the higher elevations of the Santa Catalina, Santa Rita, Chiricahua, and Pinaleno Mountains of the Sonoran biogeographic province. Samples of this SDS phenotype, AZ-C(II), all produced $\geq 94.7\%$ geranyl linalool. Collections from the type locality of the original collection named *R. tumiceps* are AZ-C. Only this phenotype has been collected from the vicinity of Stratton, AZ, thus *R. tumiceps* is a valid taxon and should be resurrected. We have not yet collected live soldiers of AZ-D from Arizona, but collections from Nevada with the nearly identical hydrocarbon phenotype were analyzed for soldier defense secretions. The composition from these samples was similar to that of AZ-A, averaging 82.6% geranyl linalool and 14.9% γ -cadinene.

THE EFFECT OF URBANIZATION ON THE DISTRIBUTION OF DRYWOOD TERMITES OF THE SOUTHWEST

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Drywood termites belonging to the Family Kalotermitidae are represented by four native genera and one invasive genus throughout the desert southwest and the Pacific coast (Table 1). Su and Scheffrahn (1990) provide a list of important pest species of drywood termites found in the southwest (Table 1). The western drywood termite, *Incisitermes minor* (Hagen), represents the most significant and important structural pest species in the southwest and surveys of termites collected by pest control professionals in Arizona suggest that *Marginitermes hubbardi* (Banks) may also be an important structural pest species (Table 2). Similar surveys of pest control operators in San Diego Co., CA suggest that *Incisitermes fruticavus* Rust may also be a pest on occasion (Table 2). Most of our knowledge about the biology and ecology of these arid adapted species is attributed to *I. minor* and the desert dampwood termite, *Paraneotermes simplicicornis* (Banks).

Table 1. Species of drywood termites reported in the arid southwest and Pacific coast areas.

Structural				
Genera	Species	Distribution	Pest Status	References
<i>Incisitermes</i>				
	<i>banksi</i>	AZ	no	Snyder 1920, 1926
	<i>fruticavus</i>	CA	possible	Rust 1979
	<i>minor</i>	AZ, CA, CO	yes	Banks and Snyder 1920, Light 1934c
<i>Marginitermes</i>				
	<i>hubbardi</i>	AZ, CA	yes	Banks and Snyder 1920, Light 1934d
<i>Paraneotermes</i>				
	<i>simplicicornis</i>	CA, AZ, NM, TX, NV	yes	Banks and Snyder 1920, Light 1934b, Light 1937
<i>Pterotermes</i>				
	<i>occidentalis</i>	AZ	no	Banks and Snyder 1920
<i>Cryptotermes</i>				
	<i>brevis</i>	CA ^a	yes	

^a Invasive species. Structure fumigated and probably not established.

Collections of termites found in or around structures made by Arizona and California pest control operators revealed several potential pest species. The species collected are greatly influenced by the geographical location within each state and climate. For example, all specimens of *M. hubbardi* were collected in

Tuscon and all *H. aureus* collected in San Diego Co. were from the desert areas. Clearly, drywood termites are more prevalent in San Diego, but urbanization in Arizona will certainly lead to more drywood termite infestations in the future (Table 2).

Table 2. Surveys of termites collected by pest control professional during termite inspections of structures.

Family Species	Arizona (1990-1991) ^a No. Collections (%)	San Diego Co. ^b No. Collections (%)
Kalotermitidae		
<i>Incisitermes minor</i>	6 (13.3)	27 (31.4)
<i>Incisitermes fruticavus</i>	----	2 (2.3)
<i>Marginitermes hubbardi</i>	4 (8.9)	----
Hodotermitidae		
<i>Zootermopsis spp.</i>	----	4 (4.7)
Rhinotermitidae		
<i>Heterotermes aureus</i>	31 (68.9)	3 (3.5)
<i>Reticulitermes spp.</i>	1 (2.2)	28 (55.8)
Termitidae		
<i>Gnathamitermes perplexus</i>	2 (4.4)	----
<i>Amitermes spp</i>	1 (2.2)	2 (2.3)

^a Specimens were collected by 5 different pest control companies throughout Arizona from structures.

^b Specimens were collected in San Diego county by at least 17 different companies from April to October 1992.

The increased importance of drywood termites as structural pests in the desert southwest is attributable to urbanization: human commerce, increased populations, changes in building practices, the use of non-native lumbers, and sheltered microhabitats.

From 1929 to 1931, there were 398 cases involving *I. minor* and 3,898 cases involving subterranean termites in Los Angeles county (Light 1934a). In San Diego in 1930, one company reported 29 cases of drywood termites and 89 cases of subterranean termites (Light 1934a). A review of structures treated in the Los Angeles area in 1948, indicated that 75% of the 186 structures treated were infested with drywood termites (Hunt 1949). Ebeling (1960) reported that data from termite clearance reports from 1945 to 1952 in southern California revealed that 35.4% of the structures were infested with drywood termites. He concluded that the incidence of drywood termites was increasing and cited the change in construction to wood-shingled roofs in the 1940's as one reason for the increase. Brier et al. (1988) reported that 44% of the attics inspected in Los Angeles, Orange and San Diego counties showed signs of drywood termite infestations. Review of termite inspection reports in southern California found 55% of the structures infested with drywood termites and within zip code areas percentages of infested structures ranged from 85% to 0% (Atkinson 1994, unpublished data). The general trend of infestation rates (highest to lowest) was

costal lowlands, inland valleys, high desert, low desert, and high elevations. Older urban centers showed significantly higher infestation rates than did newer developments. Another measure of the growing importance of drywood termites in urban communities is the increased use of structural fumigant sulfuryl fluoride (Vikane) in two counties in California (Fig. 1). The usage patterns probably reflect infestations of structures that occurred about 5-7 years earlier. All indications suggest that the importance of drywood termites as structural pests has dramatically increased with urbanization in the desert southwest.

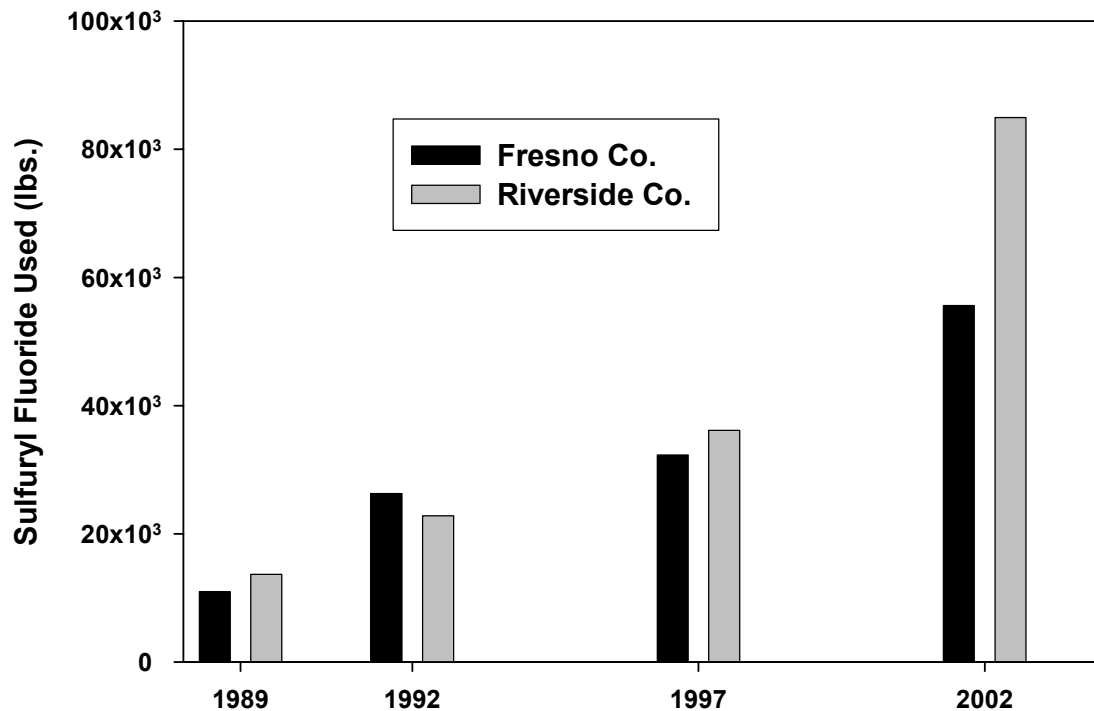


Fig. 1. The use of the structural fumigant sulfuryl fluoride (Vikane) against drywood termites in Fresno and Riverside counties in California (cdpr.ca.gov).

Urbanization and the construction of new cities have resulted in the introduction of non-native lumbers such as Douglas fir, spruce, Port Orford cedar, hemlock and redwood into desert communities. Rust et al. (1979) found that both *I. fruticavus* and *minor* preferred structural lumbers such as Douglas-fir, redwood and sugar pine to native woods such as jojoba and sugarbush. Landscaping in the urban environment also introduces plants such as sycamore, shamel ash, and walnut that serve as reservoirs and sources of alates.

Another significant consequence of urbanization is the construction of buildings that provide suitable microhabitats for drywood termites in extremely arid and hot environments. *I. minor* and *fruticavus* are extremely tolerant of desiccating conditions with cuticular permeability $< 3 \mu\text{g water/cm}^2/\text{hr/mmHg}$ (Rust et al.

1979). It is unlikely that building structures in desert areas contributes to more favorable environmental conditions as they relate to water regulation. However, studies suggest that structures create microenvironments that allow the termites to survive extreme temperatures. Exposures to 46.1° C provided 100% kill of nymphs of both *I. minor* within 210 min (Rust and Reiersen 1998). Drywood termites will move to avoid high temperatures (Rust et al. 1979, Cabrera and Rust 1996). Even brief exposure to -21.3° C provides 100% kill of *I. minor* (Rust et al. 1997). Shade, thick walls, and air conditioning provided by structures enable drywood termites to survive whereas populations in natural settings would be seriously compromised.

Recent collections of *I. minor* from large pieces of wood and structures in Grand Junction, CO, support the notation that temperature may be the important factor limiting the distribution of *I. minor* (Jones 2004). Urbanization produces human commerce and the necessary transport of colonies and reproductive alates, large pieces of preferred food sources, and cooler microhabitats to permit desert southwestern drywood termites to survive. In the future, their importance as structural pests in this region will continue to grow.

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GNATHAMITERMES AND TWO RELATED NEW GENERA FROM THE AMERICAN SOUTHWEST AND MEXICO

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The genus *Gnathamitermes* as presently recognized includes four species: *G. grandis* and *G. nigriceps* from Mexico, *G. tubiformans* from Texas and *G. perplexus* from California to western Texas. However the species *G. perplexus*, as the name implies, includes a confusing degree of variability and holds six synonyms: *acrognathus*, *acutus*, *confusus*, *fuscus*, *infumatus*, and *magnoculus*. Extensive new collecting over the entire region and careful morphological study revealed that *acutus* and *infumatus* are valid *Gnathamitermes* species requiring resurrection; however, *acrognathus* belongs to a valid new genus, and *tubiformans* and two other new species constitute another new and separate genus.

STUDENT SCHOLARSHIP RECIPIENTS

Regency Ballroom C & D

Moderator

Shripat Kamble

University of Nebraska, Lincoln, NE

UNDERSTANDING ANT COMMUNITY STRUCTURE IN URBAN ENVIRONMENTS

Eric S. Paysen

Clemson University

Observations from three studies are discussed to give insight and stimulate research on the interactions among exterior urban habitats, pest ants, and non-pest ants. At Clemson University, an extensive survey of ants was conducted around three buildings with severe indoor and outdoor Argentine ant, *Linepithema humile*, infestations. Forty-eight hand-collected samples were taken from 10 different habitat types. While *L. humile* was present in 43 of 48 collections, 27 other species were found in close proximity to well-established Argentine ant trails. Nine of these are known as urban pests and have potential for population explosions. However, 18 species are not pests or are known only as occasional invaders of structures. Three species, *Pachycondyla chinensis*, *Paratrechina fasionensis* and *Forelius pruinosus* show potential as beneficials. These species are dominant keystone species in natural environments and appeared to displace *L. humile* in areas within the study that were otherwise dominated by it. The second study took place in Clemson, South Carolina, and looked at the competition between the red imported fire ant, *Solenopsis invicta*, and a native field ant, *Formica schaufussi*, at frozen mealworm baits. In direct confrontations at bait stations, *F. schaufussi* did not challenge *S. invicta*. However, *F. schaufussi* exhibited a different food-gathering strategy and schedule. In baits placed equidistant from nests of each species, *F. schaufussi* out-competed *S. invicta* in both number of baits discovered (4/57) and number of baits retrieved (3/56), and might be preadapted for competition with *S. invicta*. *F. schaufussi* and the other closely related species in the *Formica pallidefulva* species complex show excellent potential as beneficials. In the third and ongoing study, the effects of disturbance on ant-community properties (diversity, abundance, and morphology) are being examined at transitions from naturally

vegetated forests to artificially maintained grasslands in the Great Smoky Mountains National Park. Several species that are known as pests in urban settings coexist with approximately 40 other species. Species assemblages change across the transition, with nearly no overlap between habitat types. Further study will quantify changes in community structure and model abiotic and biotic habitat characteristics to predict ant trends. The studies discussed here have demonstrated that in urban settings non-pest species with high diversity and abundance can coexist with and out-compete pest species such as *L. humile* and *S. invicta*. Overall, the biodiversity and ecology of pest and non-pest ants in urban environments is poorly understood. With nearly 600 species of ants described from the United States that seldom or never enter structures, there is huge potential for beneficial competition with the 30 structure-invading species. The increasingly widespread use of nonrepellent and broadcast insecticides in ant-management practices might be affecting beneficial species negatively, and the study of their interactions and potential positive qualities should not be overlooked when developing IPM programs targeting pest ants.

VARIATION IN INTERCOLONY INTERACTIONS IN *RETICULITERMES FLAVIPES* (KOLLAR) (ISOPTERA: RHINOTERMITIDAE)

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Behavioral and genetic studies of *Reticulitermes* spp. and other termite species suggest that termite colonies may be able to merge together. To determine if colonies of *R. flavipes* can merge and whether reproductives from the two original colonies may interbreed with each other, we performed a laboratory experiment in which large fragments of colonies were paired together and provided with a common foraging arena. The nature of the interaction between workers and whether colonies fused were observed. 55% of the 20 colony pairing assays we performed demonstrated a lack of aggression. Colony pairings that demonstrated a lack of aggression fused. In fused colonies unrelated nestmates shared food resources, participated in trophallaxis, and tended unrelated brood. Microsatellite molecular markers were utilized to determine whether the fused colonies interbred. Analysis of the immatures and eggs within fused colonies found that all progeny arose from reproductives originating from only one of the two colonies that merged, indicating that reproductives from the two original colonies did not interbreed. Our results show that under laboratory conditions colony fragments of *R. flavipes* may fuse in some cases. Our results also demonstrate that fused colonies can produce new

functional replacement reproductives. This is the first time that two separate colonies that have fused have been reported to lay eggs and produce new larvae. The molecular data supports the idea that after two colonies merge, all progeny arise from reproductives originating from only one of the original colonies. Our evidence, however, does not exclude the potential for reproduction among inter-colonial secondary reproductives. Given more time or a larger sample size, secondary reproductives from both colonies may have been produced and interbred. Merging may provide colonies with an adaptive edge by increasing colony size and increasing the number of individuals that can care for brood and developing nymphs.

HUNGER IN *SOLENOPSIS INVICTA* BUREN (HYMENOPTERA:FORMICIDAE) AND THEIR BEHAVIORAL RESPONSE TO TWO BORIC ACID LIQUID BAITS

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To help manage red imported fire ant, *Solenopsis invicta* Buren, invasion into sensitive areas, scientists have developed several types of pest management systems, including baits. Baits have three main advantages: baits require very low concentrations of insecticide, eliminate the need to find the nest, and provide suppression of the entire colony, instead of just foraging workers. Along with very popular granular baits such as Amdro, liquid and gel baits are also available. Few research projects examine liquid and gel baits even though there is some evidence that they may be more efficient than granular baits, especially in areas with little water availability. Specifically, red imported fire ants will collect five times more liquid than solid food while foraging; therefore, liquid baits may infiltrate the mound faster than granular bait.

In laboratory bait-acceptance studies, food is often withheld to simulate natural foraging behavior; however, the period of starvation varies with each study. In order to accurately test liquid and gel bait effectiveness in the lab, we determined starvation time required for laboratory fire ants to simulate foraging ants in the field. We tested two types of commercial baits: Terro Ant Killer (Senoret Chemical Company, St. Louis, MO) and Dr. Moss's Liquid Bait System (J.T. Eaton and Co., INC., Twinsburg, OH). Twenty-percent sugar water was used as an untreated control. Laboratory ants were weighed individually and fed, and amount consumed was measured. For comparison, field ants (control ants) were collected and immediately measured in the same way. Also, we wanted to determine if mass of fire ant could be associated with amount of bait consumed. The density and viscosity, a neglected topic in discussions regarding insect diets and liquid baits, of each bait were measured at 20 C and compared with the amount of liquid consumed per ant. Lastly, a field test was performed to quantify

foraging behaviors towards three bait treatments. We placed vials, one for each bait treatment, next to foraging trails as a choice test. Individuals were counted at each vial after 20 and 60 min, and total amount of bait taken was calculated. The research described in this paper will provide data on the physical properties of selected baits, which may be used to predict the response of ants to different types of liquid baits.

The densities of sugar water, Dr. Moss, and Terro were 1.051 ± 0.004 g/mL (mean \pm SEM), 1.287 ± 0.010 g/mL, and 1.354 ± 0.006 g/mL, respectively. The viscosity, measured in centipoises, of each bait treatment varied in the same order (sugar water < Dr. Moss < Terro) but more drastically (1.7, 32, 400 cP, respectively). Initial weight of fire ants can be used as a predictor of how much sugar water they will consume in the laboratory ($R^2 = 0.77$, $F = 95.5$, $P < 0.001$). Sixty-six percent of ants (or 34 ants) fed after 72 hours of starvation, 61% (or 24 ants) fed after 96 hours of starvation, and 45% (or 34 ants) of control ants fed. When the amount consumed by ants offered all bait types were compared, no significant difference was found between those starved for 96 hours and control ants ($P = 0.987$). Significant differences were found between both 96 hours and 72 hours ($P = 0.027$), and 72 hours and control ants ($P = 0.05$), indicating that 96 hours of withholding food is ideal. Thirty-five percent (or 15 ants) of all ants offered Dr. Moss were observed to feed compared to 62 (or 46 ants) and 66% (or 31 ants) of ants offered Terro and sugar water, respectively. Ants consumed sugar water (0.242 mg ± 0.04 ; Mean \pm SEM) more readily than Terro (0.081 mg ± 0.05 ; Mean \pm SEM) and Dr. Moss (0.112 mg ± 0.07 ; Mean \pm SEM). In the field choice test, correlations exist between the number of ants counted at vials and amount consumed. A significant relationship was found between the number of ants visiting sugar water vials at 20 minutes and amount consumed ($R^2 = 0.971$, $F = 101$, $P = 0.002$), but the number of ants visiting Dr. Moss and Terro vials at 20 minutes was not related to amount consumed ($R^2 = 0.107$, $F = 0.480$, $P = 0.526$; $R^2 = 0.541$, $F = 4.718$, $P = 0.096$). At one hour, the number of ants visiting both baits and sugar water were significantly correlated with amount consumed (sugar water: $R^2 = 0.887$, $F = 31.4$, $P = 0.005$; Dr. Moss: $R^2 = 0.757$, $F = 15.6$, $P = 0.011$; Terro: $R^2 = 0.967$, $F = 145$, $P < 0.001$).

Ants exhibit different feeding behaviors when they feed on formulated liquid baits than when feed on sugar water. However, physical properties of baits may be a factor in this change. We highlight the difference in ant behavior but are unable to explain if it is the presence of the toxicant or due to the physical properties. Future research will focus on isolating the effects of physical properties of formulated and non-formulated liquid baits from toxicant effects. We will determine how viscosity of liquids affects ant feeding behavior.

TERMITES, THURSDAY SESSION

May 20, 2004

Regency Ballroom B

Moderator
William D. McClellan
DuPont

A SCREENING METHOD FOR INHIBITORS AGAINST FORMOSAN SUBTERRANEAN TERMITE CELLULASE SYSTEMS *IN VIVO*

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Cellulose, a main structural constituent of plants, is the major nutritional component for wood-feeding termites. Enzymatic hydrolysis of cellulose to glucose occurs by the action of cellulases, a mixture of the three major classes of enzymes including *endo*-1, 4- β -glucanases, *exo*-1, 4- β -glucanases and β -glucosidase. Lower termites such as the Formosan subterranean termite, *Coptotermes formosanus* Shiraki, require cellulolytic protozoa to efficiently digest cellulose for survival.

Our effort was to determine if termites could be controlled by administration of cellulase inhibitors. Some reported compounds such as gluconolactone, conduritol B epoxide and 1-deoxynojirimycin are potential cellulase inhibitors but they have only been tested *in vitro*. We developed a simple *in vivo* method to test the inhibitory ability of the designated chemicals to act on β -1, 4-glucosidases, one class of cellulase. Fluorescein di- β -D-glucopyranoside was used as the artificial enzyme substrate and the fluorescent intensity of the reaction product (fluorescein) quantified with an automated fluorescence plate reader. Several known β -1, 4-glucosidase inhibitors were tested and their

inhibitory potential were determined. Endogenous cellulase activity, apart from the protozoa's contribution is also discussed.

EFFICACY OF TERMIDOR FOR THE MANAGEMENT OF ARBOREAL TERMITE INFESTATIONS

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Since its introduction in March of 2000, fipronil, the active ingredient in Termidor, has shown excellent activity in the control of subterranean termites. In 2001, the discovery of a newly introduced species (*Nasutitermes costalis* Dudley) in Broward County Florida gave added importance to the control of termites with above ground nesting habits. Termite control trials initiated during this time in Puerto Rico evaluated the field efficacy of several application methods directed to the carton, basal tree, satellite trees and individual foraging tubes and observed 1 year post treatment. Data points taken during this period were binary; noting presence or absence of activity. Direct applications and basally applied treatments to above ground carton nests gave excellent control over the period of observation. Treatments to satellite trees and individual foraging tubes also gave good results but limited replicates would necessitate further research to confirm effectiveness. Data from these trials was submitted to the EPA and the treatment of arboreal termites is currently permissible.

DELINEATION AND MANAGEMENT OF A *RETICULITERMES* SP. AERIAL COLONY

Jerry Bowen & Brad Kard
Oklahoma State University

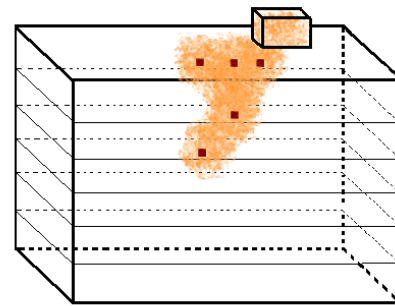
Reticulitermes sp. (Isoptera: Rhinotermitidae) are subterranean in nature and typically found in below-ground colonies. Aerial colonies are rare. These termites build tunnels of mud, wood, paper, saliva, and feces to protect them while foraging above ground for cellulose. Tunnels also serve to conserve moisture in the environment (Bennett et al. 1988). This becomes a multi-billion dollar-a-year problem when termites mistake our structures for normal cellulose sources (DowAgrosciences 1998-2004). Structural termite infestations are managed by a variety of methods including chemical and physical barriers, as well as baits.

A *Reticulitermes flavipes* colony was identified in a six-story, 100-unit apartment building in Oklahoma City, Oklahoma (Fig. 1). The Oklahoma Housing Authority

has been attempting to eliminate a termite infestation from the building in this study for nearly 10 years. Multiple termiticide treatments have been applied to the soil around the building. To facilitate the suppression and possible eradication of this colony, its foraging territory was delineated using 'mark-release-recapture' techniques (Grace 1990, Forschler and Townsend 1996, Lewis 1997), and was shown to include the fourth through sixth floors and the rooftop mechanical room (Fig. 2).



Fig. 1. – Classen Center, Oklahoma City, OK.



- — Location of Monitoring Station
- — Approximate Foraging Territory

Fig. 2. – Approximate colony foraging territory relative to monitoring stations

Two different monitoring station configurations, consisting of two container sizes, were fabricated for interior use: large (15.0 cm diameter x 7.0 cm tall) for areas inaccessible to building tenants (elevator shafts; mechanical room), and small (10.0 cm diameter x 7.0 cm tall) for inside occupied apartments. A cardboard roll was placed inside each container, moistened with distilled water, and the container lid sealed with electrical tape before placement to maintain moisture. Two large interior stations were placed in the rooftop mechanical room, and one station in the bottom of each of two elevator shafts. Interior monitoring stations were inspected bi-weekly.

Thirty-seven plastic monitoring stations containing cardboard and wood were assembled on site and installed in the soil next to the building. Termites can access the cardboard and wood through its open bottom or series of longitudinal pre-drilled holes in its side. Seventy-three additional commercial plastic monitoring stations (Termitrol®) completed the grid pattern over the entire site. Tops of the commercial monitoring stations are flush with the soil surface, facilitating lawn maintenance. A total of 110 exterior stations were installed (Fig. 3)

Following delineation of the colony foraging territory, an experimental insect growth regulator (IGR) bait contained in proprietary plastic feeding stations was emplaced in an attempt to eliminate the colony. Bait matrix was moistened with distilled water and the feeding stations were attached to apartment walls directly

over active termite locations. The perimeter around the base of each feeding station was sealed to the wall with caulk to minimize air flow and retain moisture. Monitoring stations with previous or current termite activity were connected to bait feeding stations with clear plastic tubing. Thus, potentially active monitoring stations were not disturbed. Baiting is ongoing and will continue as long as termites remain active, in an attempt to eliminate this colony.

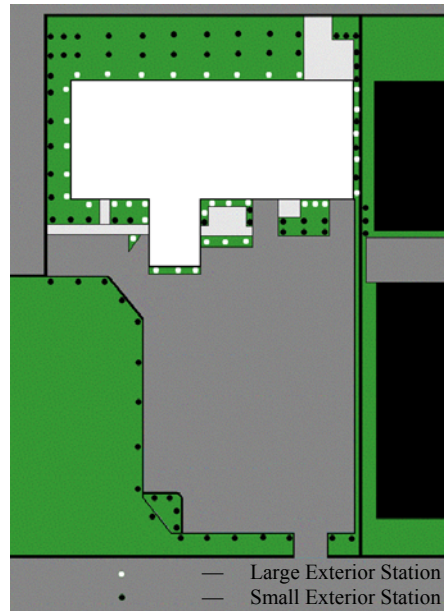


Fig. 3. – Aerial View of Exterior Station Location

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TERMIDOR EFFICACY THROUGHOUT THE UNITED STATES WHEN APPLIED AS AN EXTERIOR PERIMETER AND LOCALIZED INTERIOR TREATMENT

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Starting in 1997 with Experimental Use Permits (EUPs), the excellent termite activity of fipronil branded as Termidor was first determined. These field research trials were some of the first research to show that fipronil had effects on termites away from the treated area. Following this research, some homes were treated as exterior perimeter only, or as exterior perimeter plus local interior treatments. Based on this research, and field trials from urban entomology researchers, the termite activity of Termidor was determined. In May of 2001, an EUP was issued and protocol developed that investigated the applications of Termidor either as an exterior perimeter or as an exterior perimeter and localized interior treatment. Applications and inspections were supervised by urban entomologists, either university professors or industry consultants. All structures were monitored for termite activity monthly or every 2 months post treatment through 6 months, and then every 2 months after that to 2 years. Data were collected on different construction types, termite species, environmental conditions and Termidor use rates. Results from 2 years of inspections show excellent efficacy. Homes that received the exterior perimeter and localized interior treatments showed 100% termite control. Homes that received only exterior perimeter applications showed a mean of 98.5% termite control. The proposed label for this new use pattern will require exterior perimeter applications and local interior treatments to areas that have live termites. The efficacy data and proposed label have been submitted to EPA for registration consideration.

FORAGING BEHAVIOR OF THE FORMOSAN SUBTERRANEAN TERMITE

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The success of baiting programs depends on the ability of the termites to find and consume the bait, and to spread the slow-acting toxin to nestmates through trophallaxis. However, in some cases, termites may not find the bait stations for several months or longer, causing homeowners to lose time and money using a pest control technique which is having no effect on the termite infestation in their homes. Certain semiochemicals have been identified that elicit trail following

behavior in the Formosan subterranean termite, *Coptotermes formosanus* Shiraki. These semiochemicals could potentially be used to increase the probability that foraging termites will discover bait stations. This study evaluates the effects of semiochemicals on termite foraging behavior.

The foraging behavior of the Formosan subterranean termite was examined in both laboratory and field studies. Laboratory studies were conducted to examine the effects of different semiochemicals on the feeding, tunneling, and aggregation behavior of termites. Feeding behavior was measured by comparing weight loss due to consumption of treated and control disks in paired choice tests after 24 h. Aggregation behavior was measured by comparing the number of termites on treated and control discs at specific time intervals. Effects of semiochemicals on tunneling behavior were examined by determining if termites were more likely to construct tunnels in areas of chemically-treated sand than in areas of solvent-treated sand. Bioassays were also conducted to determine if the presence of semiochemicals in sand could direct the construction of tunnels towards a food source.

Field studies were conducted to determine how the presence of semiochemicals influenced the rate of colonization of bait stations and whether the incorporation of semiochemicals into a bait matrix had the potential to enhance the efficacy of bait products. Field studies were conducted by placing bait stations in areas of City Park where the foraging populations of termites had previously been delineated using mark-release-recapture techniques. The rate of colonization of bait stations and the consumption of the bait matrix was compared for stations with and without the semiochemicals.

RECOVERY AND EXPANSION OF SULFLURAMID-SUPPRESSED POPULATIONS OF *RETICULITERMES FLAVIPES* (ISOPTERA:RHINOTERMITIDAE)

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Department of Entomology
Texas A&M University

Populations of Eastern subterranean termites, *Reticulitermes flavipes*, were monitored over a five-year study utilizing a termite baiting system with the active ingredient, Sulfluramid. The test area consisted of a 0.4-hectare field in a suburban setting adjacent to residential structures. Four grids of 100 plastic FirstLine® monitoring stations with wooden inserts (400 total) were installed in a 10 X 10 pattern, one-meter distance between stations. Each station was monitored monthly to determine the foraging activity of subterranean termites; stations were opened and wooden monitors were removed for visual inspection. Upon detection of termite activity, monitoring stations were replaced with bait

stations containing active ingredient. Through marked recapture procedures, two distinct and separate populations, or colonies of *R. flavipes* were delineated in the course of the study. Seasonal patterns of subterranean termite foraging were recorded in the grids as the population declined over a 37-month period, until termites were no longer detected in the stations of the four grids for a three-month period.

All active ingredient bait stations were removed and replaced with plastic monitoring stations that included wooden inserts following the three months of zero termite activity in the stations in the grids. Monthly monitoring was instituted to determine the extent and rate of subterranean termite foraging recovery into the grid area. Termites were observed in monitoring stations in one of the four grids in 30 days. Within 60 days, termites were observed in two of the grids, and in all four of the grids within 120 days. Subterranean termite foraging continued to recover and expand into the existing grids; within 18 months in the recovery cycle, the number of monitoring stations with actively foraging termites exceeded the maximum number of monitoring stations with termite activity prior to Sulfluramid suppression. Two distinct and separate populations have again developed in the 24 months following active ingredient removal, but a distinct shift in termite foraging in the grid area was observed. Foraging peaks during both summer and to a lesser extent, autumn months, were observed and recorded, characterized by maximum numbers and locations of stations with incipient termite activity and those with cumulative feeding of active ingredient baiting stations. Diminished foraging was consistently observed during the February/March months, corresponding with typical colony alate production and swarming flights.

FIELD EFFICACY OF FIRSTLINE® GT PLUS TERMITE BAIT STATIONS IN THE CONTROL OF SUBTERRANEAN TERMITES

J. Ballard, C. Palmer, B. Ryser, G. Cramer, and A. Dufoe
FMC Corporation

Field efficacy data to support label claims for the control of subterranean termites (*Coptotermes*, *Heterotermes* and *Reticulitermes* species) through the stand-alone use of FirstLine® GT Plus Termite Bait Stations (EPA Reg. No. 279-3196) are provided. The bait station contained sulfluramid treated cardboard as the active ingredient at a rate of 100 ppm. Data were generated for remedial structures (structures infested with termites at the start of the study) and for preventive structures (structures not infested by termites at the start of the study but live termites were found within 25 feet of the structure). None of the structures used in this report had liquid termiticide applied for 5 years before the monitors were installed around the structure. The data used in this paper are from a series of field trials conducted by cooperating researchers. The duration of

the trials ranges from 3 to 4 years. All data collected, including initial site surveys and monthly inspection sheets, were stored in a searchable database.

It is important to understand that structural protection, a structure free of subterranean termites, is the goal of using termite bait to control termites in and around structures in this study. Structures were inspected initially and then annually for the presence of termites. Termite monitor stations and baits also became infested with termites, with one or more “cycles” (monitor then bait then monitor) occurring around some structures.

The 107 structures used in this report were from a total of 8 states (AZ, CA, FL, GA, LA, MD, NJ, and TX) representing 5 EPA regions: I, III, IV, VI, and IX .

Remedial Structures: The average amount of time for the first monitor station to be infested by termites was 10.2 months. Twenty-four structures have become un-infested with twenty-three structures completing one baiting cycle in the stations surrounding the structures. Average time to control (time from when bait first introduced) was 11.6 months.

Preventive Structures: The average amount of time for the first monitor station to be infested by termites was 22.5 months. Sixty-five structures have been through one bait cycle. The average time to no activity in stations after bait introduction was 10.2 months.

EXAMINATION OF EXTRINSIC FACTORS AFFECTING FLIGHT PERIODICITY OF THE FORMOSAN SUBTERRANEAN TERMITE

Karen E. Nix, Huisin Fei, and Gregg Henderson
Louisiana State University Agricultural Center, Department of Entomology
Baton Rouge, LA 70803

Formosan subterranean termites cause major economic problems for homeowners in the city of New Orleans. Each year from the end of April to the end of June, these invaders swarm from mature colonies in order to disperse reproductives and form new colonies. What causes them to fly during this period and why some daily flights are much larger than others have been questions asked by Louisiana State University AgCenter researchers since 1989. For the past 15 years light traps were set up at various points inside and outside of the historic French Quarter; New Orleans, Louisiana, and have been used to record daily flights during the Formosan subterranean termite alate swarming season. This information is being used to determine yearly population trends and daily flight rhythms. We wished to determine if extrinsic factors (rainfall, temperature, and moon cycles) were associated with the flight periodicity of peak swarms.

PUBLIC HEALTH PESTS

Regency Ballroom A

Moderator

Dina Richman

FMC Specialty Products Business

Philadelphia, PA

BED BUGS: MORE QUESTIONS THAN ANSWERS: A NEED FOR RESEARCH

Richard Cooper

Technical Director, Cooper Pest Solutions

351 Lawrence Station Road, Lawrenceville, NJ 08648

Bed bugs were once considered a serious pest in the United States. However, the use of persistent pesticides such as DDT and malathion led to a sharp decline in the prevalence of this pest. Consequently, by the early 70s bed bugs had been virtually eliminated as a pest in this country. In recent years, bed bugs have begun to resurface and are now considered to be a re-emerging pest. Based on observations within my own organization and discussions with technical directors of pest management firms around the country, it appears that bed bugs are becoming widely distributed at an alarming rate. In fact, one may ask whether bed bugs are a “re-emerging” pest or an existing one that is spreading out of control. Virtually no research on bed bugs has been conducted in the past 50 years, and few data exist on the insecticides registered for bed bug control. Some of the most basic issues such as pesticide efficacy, repellency and resistance are not being addressed. In addition, methods for effectively monitoring this pest are lacking. As a result, the pest management industry is developing treatment strategies based upon what each individual firm believes to be appropriate. Personal field observations suggest that bed bugs may be exhibiting behaviors that lead pest management professionals to perceive control of the pest, when in fact control measures may have failed. Continued treatment of bed bug infestations using materials and methods that lack scientific backing may not only result in inadequate control of this very difficult pest but may also select for populations that will become harder to control in the future. This presentation will review field observations that I have made, leading to more

questions than there are answers, thereby posing some very serious concerns about this increasingly important pest.

EFFICACY OF TALSTARONE™ AS A BARRIER TREATMENT TO CONTROL URBAN MOSQUITOES

Dina Richman
FMC Corporation

Talstar® liquid was used to control resting mosquitoes in laboratory and field trials. When applied to common outdoor surfaces held in the laboratory, Talstar was effective for up to 8 weeks against two mosquito species. This pyrethroid is less irritating to mosquitoes than other pyrethroids, so they will effectively die after resting on Talstar-treated surfaces in the field. Talstar liquid applied by mist blower reduced numbers of mosquitoes caught in CDC traps placed in treated versus untreated urban residential areas in Louisiana by 73% at 2 days after treatment and 43% at 3 weeks after treatment. The same treatment reduced numbers of mosquitoes caught in CDC traps placed in a treated versus untreated urban residential area in California by >80% through 3 weeks after treatment.

AREAWIDE YELLOWJACKET CONTROL

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Where numerous, certain species of yellowjackets (Vespidae) may be annoying and dangerous. Predatory species belonging to the *vulgaris* subgroup are efficient predators of Diptera, Orthoptera and immature Lepidoptera, altering their foraging habits and becoming scavengers and seasonally pestiferous as the density of worker wasps/area increases as the abundance of native prey declines. Some species have a propensity to construct their colony in structural voids. Interactions with humans increase with location and wasp density, and such interactions may result in intentional or accidental stings (Fig. 1). Although <5% of humans are sensitive or hypersensitive to wasp venom, this represents large numbers of people (Fig. 2). Children are at greater risk.



Fig. 1

<u>SENSITIVITY TO HYMENOTERA VENOM</u>	
Of 3236 subjects for venom skin test (VST):	
- 89% had historical systemic reactions	
- 74% positive to bees or wasps	
- 52% positive to yellowjackets	
- 1.4% (45) hypersensitive,	
of which 8 (0.25%) were severe	
Lockey et al, 1974	

Fig. 2

Preventive and remedial strategies to control yellowjackets were evaluated. Early-season queen removal (i.e. trapping) had no observable or statistical effect on resultant worker numbers. Late-season trapping or baiting with sweet liquids captured or killed large numbers of worker wasps but did not provide control different from that of the natural seasonal decline of populations.

Bait comprised of ground chicken or fish-flavored pet food + small amounts of selected insecticides rapidly reduced the number of foraging yellowjackets, presumably killing workers and brood via trophylactic exchange. The mechanisms involved with control of yellowjackets with bait may be similar for other social Hymenoptera, such as some species of ants. Contrary to previous reports, our tests indicate that when in scavenging mode, *V. pensylvanica* and perhaps other *vulgaris* subgroup species, recruit nestmate workers to acceptable foods.

As measured by bait acceptance, most insecticides were repellent, the concentration of toxic adulterant being critical. As shown in Fig. 3 (below), control was related to rate of acceptance (i.e. food take), and was greatest with insecticides prepared at 1×10^{-4} to $1 \times 10^{-3}\%$ (10 to 100 ppm). Higher rates were ignored, and repellency was substantiated by reduced landing rates and 'time on bait' as concentration was increased. This is approximately the same effective rate of insecticide adulterant in sucrose water for control of the Argentine ant, *Linepithema humile*.

<u>Candidate Bait Actives (%)</u>	
Spinosad	1×10^{-3} to 1×10^{-4}
Fipronil	1×10^{-3} to 1×10^{-5}
Imidacloprid	1×10^{-3} to 1×10^{-4}
Thiamethoxam	1×10^{-4}

Fig. 3

Bait Actives in Pet food ($1 \times 10^{-3}\%$)	
<u>Ineffectual</u>	
Bifenthrin - repellent	
Calypso® - minimal mortality	
<u>Readily foraged</u>	
Acetamiprid, imidacloprid, pyroproxifen, spinosad	

Fig. 4

Although rate of application and the numerical degree of population reduction were not previously reported, we confirmed published reports that protein bait containing fipronil may provide outstanding yellowjacket control. However, baits containing the closely related Calypso[®] or bifenthrin (Talstar[®]), on the other hand, were repellent or ineffectual. Initial trials with baits containing low rates of acetamiprid, imidacloprid (Merit[®]), pyriproxyphen (Archer[®]) and spinosad (Naturalyte[®]), were readily foraged, suggesting the likelihood of good control with these substances. Probably because of the low rates involved, there was no apparent difference in the amount foraged when baits were made with EC, SC or WP formulations. The results support the notion that it may be possible to commercialize an effective yellowjacket bait.

THE MAXFORCE[®] TICK MANAGEMENT SYSTEM[™] AND ITS ROLE IN REDUCING THE INCIDENCE OF LYME DISEASE

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Bayer Environmental Science and the Centers for Disease Control (CDC) have been working since 1996 on an innovative system designed to break the cycle of Lyme disease. Lyme disease is the most frequently reported vector-borne illness in the United States. It is an infection caused by the corkscrew-shaped bacteria, *Borrelia burgdorferi* that are transmitted by the bite of the black-legged deer tick, *Ixodes scapularis*. This tick is responsible for transmitting Lyme disease to humans. The Maxforce Tick Management System reduces questing tick populations and the number of infected rodents. Ultimately, the goal is to reduce the risk of Lyme disease for homeowners. The system works when rodents are attracted to and enter a bait box. While investigating the box the rodent receives a small dose of insecticide. The dose is enough to control *I. scapularis* on rodents for approximately 40 days. Thus, the mouse is protected and the tick is eliminated. Trained professionals place the child resistant boxes out in the spring, return in the summer with replacement boxes, and again in the fall to remove the second set of boxes.

Numerous field efficacy trials have been conducted in the Northeastern United States. boxes were applied per label directions (30 ft apart near the edge of maintained landscaping and woodlots) in late spring and mid summer coordinated with *I. scapularis* immature development. Tick activity at treated and untreated sites was determined by surveying the area approximately 30 days after placement of boxes. Surveys were conducted by capturing live animals and counting the number of ticks on the hosts. Sampling for questing ticks was also done by dragging a cloth among vegetation and on ground surfaces and recording the number of ticks that attached to the cloth. In some trials, boxes

were weighed before and after placement to determine the amount of attractant bait consumed.

Mason's Island Connecticut: At this test site, field studies have been ongoing since 1999. From 1999 to 2001, the percentage of infected ticks was significantly reduced following placement of boxes. Before treatment infection rates in nymphal ticks was 25%, but by the second year infection was only 7% and by the 3rd year <2%.

In 2003, 170 properties were treated with tick boxes. In untreated areas, 8.4 ticks/mouse were recorded compared to 0.4 ticks/mouse in treated areas. The tick infestation rate was 83% in untreated sites and only 15% in treated areas.

Needham Massachusetts: Trials at this site were initiated in 2000 and the same treated and untreated properties have been in the study for the last 3 years. Both tick burdens on rodents and the number of host-seeking ticks were greatly reduced on treated properties compared to untreated control sites.

The Maxforce Tick Management System was launched in the Northeastern United States and upper Midwest for the 2004 tick season. Commercialization of this innovative system would not have been possible without the combined efforts of CDC, Bayer Environmental Science, and various other researchers.

COMPARATIVE EVALUATION OF RESIDUAL ACTIVITY OF SIX PYRETHROID PRODUCTS ON FOLIAGE AND CONCRETE SURFACES AGAINST ADULT *CULEX QUINQUEFASCIATUS* MOSQUITOES

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Barrier treatment has become increasingly popular in mosquito control programs in recent years. It allows an insecticide to be delivered to where mosquitoes are resting and harboring.

Six pyrethroid-based residual products were evaluated at laboratory against adult *Culex quinquefasciatus*: 1) deltamethrin WDG, 0.03, 0.06%, 2) lambda-cyhalothrin CS, 0.03%, 3) deltamethrin SC, 0.01, 0.03 and 0.06%, 4) bifenthrin FL, 0.06%, 5) beta-cyfluthrin SC, 0.05%, and 6) beta-cyfluthrin WP, 0.1%.

Each insecticide was applied onto concrete block and plant foliage at a rate of 1 gal/100 ft² using a compressed-air sprayer. Treated surface dried and aged outdoors before efficacy was assessed at laboratory. Mosquitoes were allowed

to rest on treated surface for 1 hour before they were transferred to a clean container. Mortality was determined at 24 hours.

On concrete, all treatments provided high levels of knockdown and mortality at 1 day post-treatment. At 9 days post-treatment, only 0.03 and 0.06% deltamethrin SC achieved greater than 80% mortality. On foliage, all treatments provided high levels of mortality at 1, 7, and 30 days post-treatment. The effects decreased considerably by 60 days, with 0.06% deltamethrin SC providing the highest level of mortality at 83.5%.

SUMMARY OF 2003 FIELD TRIALS ON THE USE OF TERMIDOR® SC IN THE CONTROL PAPER WASPS AND VOID NESTING YELLOW JACKETS

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Pest Management Professionals are seeking an effective alternative to Ficom® dust (bendiocarb) which the Pest Management Industry will loose as a control tool for yellow jackets, paper wasps and hornets. This field study shows through labeled site use the efficacy of Termidor® SC (fipronil) on yellow jackets and paper wasps. Comparative control results were measured against Ficom and Suspend SC® (Deltamethrin). Three different studies were conducted using different treatment groups and controls.

It appears that Termidor® SC may be a suitable material to control existing paper wasp and yellow jacket nests and may prevent the establishment of nests of paper wasps. Data from this study will be submitted to the Environmental Protection Agency in order to add yellow jackets and paper wasps to the Termidor® SC label.

VIKANE® GAS FUMIGANT (SULFURYL FLUORIDE) FOR ERADICATING STRUCTURAL INFESTATIONS OF EXOTIC OR UNUSUAL ARTHROPOD PESTS

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Vikane® gas fumigant (sulfuryl fluoride) has been used extensively for more than 40 years to eliminate structural infestations of drywood termites, wood-destroying beetles, and other common household pests. Vikane is also an important pest

management tool for eradicating pervasive infestations of exotic or unusual arthropods of economic or medical importance isolated within structures to prevent spread and establishment of these pests. During the past 2 years, fumigation with Vikane has eliminated the termitid termite *Nasutitermes acajutlae*, the Chilean recluse spider *Loxosceles laeta*, and the bed bug *Cimex lectularius* infesting one yacht and two single family homes, respectively, in Florida. Infestations were extensive throughout each structure, infesting voids, such as the sealed yacht hull, inaccessible for localized treatment with residual insecticides. The infestations required immediate and complete remediation; the yacht was to be sold and the occupants of both homes were under medical treatment for severe reactions to the spider or bed bug bites.

All structures were thoroughly sealed using nearly new vinyl-covered tarpaulins, resulting in excellent fumigant confinement with half-loss times (HLT's) ranging from 38.5-47.5 h. Fumigations were conducted during warm weather (indoor ambient or slab temperatures of 26.6-29.4°C). During all fumigations, fumigant concentrations were measured in 2-4 locations using Fumiscope 4.2 equipped with a drying tube (Key Chemical and Equipment Co., Clearwater, FL) calibrated on-site using Vikane diluted in air to a known concentration. These measurements were used to calculate fumigant HLT and dosage accumulation. Arthropod bioassays were placed adjacent to monitored locations within the fumigated structures. Bioassay specimens were collected on-site (spider and bed bug) prior to fumigation, or surrogate specimens (*N. costalis*, provided by Dr. Rudolf Scheffrahn, University of Florida, for the yacht) were collected locally. Target dosages were determined based on label rates for the bed bug or toxicity to related genera for *L. laeta* and *N. acajutlae*. Fumigation exposure periods ranged from 19-42.5 h. Accumulated dosages were 197 mg-h/L (*N. acajutlae*), 496 mg-h/L (*C. lectularius*), and 1002 mg-h/L (*L. laeta*). Post-fumigation, all arthropods in bioassays were dead. In addition, all arthropods found live *in-situ* prior to fumigation, such as *N. acajutlae* in foraging tubes and *L. laeta* in webs, were dead. No reinfestation has been reported in any of the fumigated structures.

VIKANE® is a registered trademark of Dow AgroSciences LLC.

ANT ECOLOGY IN THE URBAN ENVIRONMENT

Regency Ballroom A

Moderator

Jules Silverman

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THE RED IMPORTED FIRE ANT, ITS INVASIVE NATURE AND ECOLOGICAL IMPACT

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The red imported fire ant (RIFA), *Solenopsis invicta* Buren, FA entered the United States around the early 1930s at Mobile, Alabama. RIFA spread from Mobile naturally by mating flights, on water during floods, and, artificially, through the shipment of infested cargo, especially nursery stock. Currently, the RIFA infest more than 320 million acres in 14 states (Alabama, Arkansas, California, Florida, Georgia, Louisiana, Mississippi, New Mexico, North Carolina, Oklahoma, South Carolina, Tennessee, Texas, and Virginia). Limited infestations also occur in Arizona, Maryland, and Delaware. In addition, infestations occur in several of the Caribbean islands including Puerto Rico, the U.S. and British Virgin Islands, the Bahamas, Antigua, and Trinidad. Although the exact economic costs of fire ant damage and control are unknown, estimates for just the southeastern United States have been a half billion to several billion dollars per year. This includes the RIFA's impact in urban areas, medical costs, pesticide costs, crop and livestock losses, and damage to farm implements. Multiple queen forms (polygyne colonies) were discovered in the early 1970's and these are becoming more prevalent. Polygyne populations are 2-3 times as dense per unit area than the monogyne form and this increases the problems and economic costs caused by this pest. There is no estimate of the damage and destruction caused by fire ants to biodiversity but it is believed to be substantial. Fire ants are highly aggressive when their nests are disturbed and cause painful stings to humans, pets, domestic animals and wildlife. They occur across a wide variety of ecological habitats and are most commonly found in open, sunny areas where disturbance has occurred such as parks, pastures, yards and cultivated fields.

Like weeds, this aggressive, invasive ant reduces biodiversity diversity in many areas by destroying ground inhabiting arthropods including native ant species and other small animals such as ground nesting birds, turtles, rodents, snakes, and lizards. They are without a doubt, one of the most dominant terrestrial arthropods causing a multitude of problems for humans, domestic animals, agriculture and the native fauna. Although they are expanding their range, it is at a slower rate, however, based on temperature preferences, there are still many areas for them to invade such as much of the west coast and along the east coast of the U.S.

Key Words: Hymenoptera, *Solenopsis invicta*, fire ants, impact

WHITE-FOOTED ANT FEEDING PREFERENCES AND PESTICIDE EFFICACY TRIALS

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Two-choice, random-position preference tests were performed on white-footed ants (WFA) (*Technomyrmex albipes*) trailing on the exterior walls of buildings. Sucrose (25% w/v) was preferred over 10%, 15%, and 20% sucrose and 40% sucrose over 25% sucrose. There was no significant preference in pairings of 25% and 50% sucrose. There was no preference between 2% EtOH + 25% sucrose over 25% sucrose alone. Fructose was preferred over maltose at 25% each, while 25% sucrose was preferred over 25% fructose, and 40% sucrose was preferred over 40% glucose. There were no significant preferences between 25% sucrose or 25% fructose versus Uncle Albert's Super Smart Ant Bait® (no a.i.), or 25% fructose versus and Drax Liquidator® Ant Bait (no a.i.). In tests with NecDew™, an artificial nectar-honeydew, compared with sucrose solutions, NecDew3 was preferred over 35% sucrose and NecDew4 was preferred over 40% sucrose. There were no observed preferences with 1-7% concentrations of disodium octaborate tetrahydrate (DOT) in 25% sucrose solutions versus 25% sucrose. NecDew4 containing 1% DOT was highly preferred over the commercial product, Uncle Albert's Super Smart Ant Bait® having 1% DOT.

Laboratory tests conducted on small, boxed WFA colonies compared efficacy of liquid and gel baits, residual treatments, an insect growth regulator (IGR), and ultrasonic pest repellers. In one test, liquid baits including 25% (w/v) aqueous sucrose containing imidacloprid (50 ppm), NecDew™ proprietary base, containing DOT (10,000 ppm), 25% aqueous sucrose containing thiamethoxam (10 ppm), and Terro Ant Killer II® Bait (54,000 ppm sodium tetraborate decahydrate (borax)) ready-to-use (RTU) bait provided significantly higher mortality at 91%, 87%, 84% and 76% respectively than the other treatments, including liquid baits including 25% aqueous sucrose containing thiamethoxam (1 ppm), and Drax Liquidator® Ant Bait (10,000 ppm orthoboric acid), a gel bait

containing noviflumuron SC (5000 ppm) IGR, residual treatments including Talstar® Lawn and Tree Flowable (600 ppm bifenthrin), Termidor® SC (600 ppm fipronil), and Conserve® SC (800 ppm spinosad), Lentek Ultrasonic® pest repellents, and liquid bait, surface, and gel untreated controls. In a second test, NecDew™ liquid bait containing thiamethoxam (10 ppm) provided significantly higher mortality at 100%, than all other treatments, including liquid baits including PT381B Advance Liquid Ant Bait (54,000 ppm borax) RTU bait, imidacloprid ant bait instant granules (50 ppm), and Pre-Empt® (50 ppm imidacloprid) RTU bait, and surface treatments including Termidor® SC (1200 ppm fipronil), indoxacarb technical (500 ppm), DeltaDust® (500 ppm deltamethrin), and Demand® CS (600 ppm lambda cyhalothrin), gel treatments, including Maxforce® Ant Bait Gel (10 ppm fipronil), Combat® Quick Kill (100 ppm fipronil) RTU ant bait stations, noviflumuron SC (5,000 ppm), indoxacarb technical (500 ppm), and liquid bait, surface, and gel untreated controls.

Test populations of WFA isolated by a band of Tree Tanglefoot® in coconut palms compared efficacy of liquid baits and residual products. Liquid baits included NecDew™ (100 ppm thiamethoxam), NecDew™ (100 ppm imidacloprid), and Drax Liquidator® Ant Bait (10,000 ppm orthoboric acid), and residual treatments applied to 61 cm-high painted bands around the trees included Talstar® Lawn and Tree Flowable (600 ppm bifenthrin) and Termidor® SC (600 ppm fipronil). Populations were determined by counting ants feeding upon wicks of bait containers. In comparison with pre-treatment means, at 28 days after treatment, the products with the greatest mean percent population reduction were NecDew™ with thiamethoxam, NecDew™ with imidacloprid, Talstar®, Drax Liquidator®, and Termidor®. The crowns were treated and the 61 cm-high painted bands were re-treated with the 2 residual products 42 days after the initial treatment, and the baits were no longer refreshed. At 63 days (=21 days after treating the crowns), when compared with pre-treatment means, the products with the greatest mean percent population reduction were Talstar®, NecDew™ with imidacloprid, NecDew™ with thiamethoxam, and Termidor®, while the populations treated with Drax Liquidator® increased.

THE ROLE OF THE PHYSICAL ENVIRONMENT IN THE SUCCESS OF THE INVASIVE ARGENTINE ANT

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Hypotheses concerning the success of insect pests commonly emphasize the importance of biotic interactions (esp. escape from natural enemies) but often fail to consider in detail the role of abiotic factors. Although physical conditions can set clear limits on the distributions of species, fine-scale variation in the abiotic environment can also be important in determining local patterns of pest

abundance. This talk will address the interplay between interspecific competition and the physical environment with respect to whether seasonally dry mediterranean environments in California become invaded by the Argentine ant (*Linepithema humile*). Data from observational experiments, manipulative field experiments, and laboratory studies will be discussed. Taken together these findings demonstrate that hot, arid conditions seriously impinge on the Argentine ant's ability to invade. At least in arid regions, control strategies might be aimed at manipulating anthropogenic alterations of the physical environment such that pest species, such as moisture loving invasive ants, might be managed.

REGIONAL DISTINCTIONS IN INVASIVE ARGENTINE ANT POPULATIONS

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The Argentine ant is a particularly troublesome invasive species. Since its worldwide introduction into regions with Mediterranean, subtropical and mild temperate climates, *L. humile* has assumed a unicolonial structure, producing large multiple-queen colonies that lack clear boundaries due to a general absence of intraspecific aggression. Invasive *L. humile* populations have disrupted native ant and other arthropod communities through numerical dominance due, in large part, to the absence of colony borders. They are considered serious agricultural pests, particularly of citrus, as they tend crop feeding homopteran species and interfere with their natural enemies, and are an important urban pest, often infesting human residences and places of business.

Extensive Argentine ant supercolonies spanning hundreds to thousands of kilometers have been reported in California and southern Europe. By contrast, our examination of *L. humile* in portions of the eastern U.S. (North Carolina, South Carolina and Georgia) revealed smaller, widely scattered, mutually aggressive colonies. We suspect that regional differences in *L. humile* population structure are due to climatic and possibly biotic influences, and we provide evidence that low winter temperatures prevent Argentine ant establishment beyond human-altered habitats. In Mediterranean climates, where most Argentine ant populations have been reported, average winter temperatures exceed 0°C and foraging activity is observed year-round. We hypothesize that continuously active colonies expand to the point where encounters with other colonies occur, leading to fusion and the dissolution of colony boundaries. Our data reveal that mutually aggressive colonies accept conspecific workers and queens after a period of nonlethal aggression. Therefore, the extensive supercolonies described within habitats with Mediterranean climate may result from different introductions followed by boundary expansion and intercolony fusion.

MOLECULAR TECHNIQUES FOR TERMITE IDENTIFICATION

Regency Ballroom B

Moderator

Mike Rust

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Riverside, CA

WINDOWS ON THE UNDERWORLD: DNA MARKERS PRESENT NEW VISTAS FOR TERMITE BIOLOGY AND MANAGEMENT

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Despite the biological, ecological and economic importance of termites, many aspects of their biology remain poorly understood, including such basic areas as natural history and taxonomy. This is especially true of the subterranean termites (Rhinotermitidae), because their cryptic nesting and foraging habits hinder study of their natural history, and because there is a paucity of clear, accessible morphological characters for distinguishing among many species.

Fortunately, the application of molecular genetic techniques holds great promise for elucidating many areas of termite biology, in both the basic and applied arenas. Molecular (DNA) markers are now routinely used to investigate numerous aspects of the behavior, life history and evolution of a wide diversity of organisms, and they are being adopted with increasing frequency to address termite evolution and taxonomy, to infer colony breeding structures, to delineate colony boundaries, and to fingerprint colonies for temporal and spatial tracking.

There is an almost bewildering array of molecular markers available, each with its own strengths and weaknesses. Because of the hierarchical nature of genetic variation in social insects – individuals are grouped into colonies, which in turn are assembled into populations, which collectively form species, and so on up through the tree of life – careful consideration must be given to the choice of markers for a particular question. In addition, use of the appropriate genetic

markers is most informative when the hierarchy of genetic structure is taken into account during both sampling and data analysis. Since genetic variation at each level in the hierarchy is determined by processes at lower levels, we can make inferences about the natural history and evolution of termites with proper measurement of genetic variation at different levels and application of population genetic models.

The three main types of markers that have been used in studies of termite natural history and evolution are multilocus DNA fingerprinting, DNA sequence data, and microsatellite markers.

Multilocus DNA fingerprinting is extremely sensitive for detecting differences between groups of individuals belonging to different colonies, provided that individuals within colonies are close relatives (e.g., Husseneder and Grace 2001). This technique would be useful for tracking colonies over time, especially in species for which there are no microsatellite markers available. However, the extreme variability detected with this method and the dominant nature of the banding patterns severely limit its application for measuring genetic variation among populations, assessing levels of inbreeding within populations, and other typical measures of population genetic structure needed to infer important attributes of their natural history.

DNA sequences are highly useful for determining phylogenetic relationships among termite taxa (e.g., Austin et al. 2002), and, in the case of mitochondrial DNA, for determining the number of matrilineages within colonies (e.g., Jenkins et al. 1999; Bulmer et al. 2001; Vargo 2003a), measuring differentiation among populations (e.g., Vargo 2003a), and linking introduced populations with potential source populations (e.g., Jenkins et al. 2002). A very practical application of this method is accurate species identification (e.g., Szalanski et al. 2003). Apart from detecting the presence of multiple unrelated queens, these markers have limited utility for detailed analysis of the breeding structure of termite colonies. Interpretation of sequence data, especially concerning relationships within and among colonies and populations, should be based on sound characterization of the genetic variation within the various groups being compared.

The most useful class of genetic markers for examining colony and population genetic structure are microsatellites: single locus markers that are small repetitive repeats such as (AT)_n or (CTT)_n. Because of their high degree of polymorphism and codominant nature, microsatellite markers can reveal remarkably detailed information at several different levels of genetic variation from fine-scale structure within colonies to higher levels of structure among geographically distant populations. In addition, microsatellite markers lend themselves to the large battery of statistical tools available for measuring genetic structure and for inferring important attributes of an organism's natural history. Microsatellites have now been developed for a number of termite species, and these have provided important insights into colony breeding structure and

dispersal behavior, especially when combined with population genetic models (e.g., Vargo 2003a; Vargo et al. 2003), as well as the spatial organization of colonies and their interactions with neighboring colonies (DeHeer and Vargo 2004). Moreover, these markers have proven useful for “fingerprinting” colonies and tracking them over time to determine long-term colony effects following insecticide treatment (Vargo 2003b).

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MOLECULAR DIAGNOSTICS AND PHYLOGENETICS OF TERMITES

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Synonymy within termite groups and ambiguous morphological measurements can lead to incorrect identifications for various termites due to overlap, lack of diagnostic castes, or incomplete/inaccurate descriptions. While chemotaxonomic information can be useful for discriminating termites, they are often vague or specific to small niches occupied by various termite groups, and not applicable or consistent for species identifications. Molecular diagnostic methods using mtDNA have shown that they can readily, accurately, and consistently identify termite groups with reduced problems as seen in other techniques. Further, DNA used in molecular approaches can be sequenced and these data can support other methods to provide accurate phylogenetic information to elucidate inter/intra-specific variations that can be exploited to reveal cryptic relationships of termites which frequently have been either overlooked or misidentified. These powerful tools afford termite biologists or molecular biologists with the opportunity to identify specimens which they may otherwise not be able to identify morphologically, chemotaxonomically, or behaviorally.

GENETICALLY ENGINEERED TERMITE GUT BACTERIA DELIVER AND TRANSFER FOREIGN GENES IN TERMITE COLONIES

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We have isolated indigenous gut bacteria of the Formosan subterranean termite (*Coptotermes formosanus* Shiraki, Isoptera: Rhinotermitidae) and used them as shuttle systems to deliver, express and transfer foreign genes in termite laboratory colonies. We transformed the gut bacterium *Enterobacter cloacae* with a recombinant plasmid containing ampicillin resistance genes and the Green Fluorescent Protein gene. In laboratory experiments, termite workers and soldiers from three different colonies were fed with filter paper inoculated with transformed bacteria. Transformed bacteria were detected in termite guts by growing the entire gut flora under selective conditions and checking the cultures visually for fluorescence.

We have shown that: (1) transformed bacteria were ingested rapidly in less than a day and the GFP marker gene was expressed in the termite gut; (2)

transformed bacteria established a self-replicating and stable population in the termite gut for up to eleven weeks; (3) transformed bacteria were efficiently transferred throughout a lab colony, even when the donor (workers or soldiers initially fed with transformed bacteria) to recipient (not fed) ratio was low; (4) transformed *Enterobacter* were transferred into soil, however, they did not accumulate over time and the GFP plasmid was not transferred to other soil bacteria.

We are currently testing gene products for their efficacy to control termites in vivo and in vitro. Genes found to be detrimental will be engineered into natural gut bacteria and introduced to termites.

INTEGRATING MOLECULAR TECHNIQUES INTO THE PROCESS OF TERMITE MANAGEMENT: THE PROMISE AND THE PITFALLS

Brian T. Forschler
Department of Entomology, University of Georgia
Athens, GA 30602

Management of subterranean termites has always involved an element of the unknown. Inspections can be hampered by construction and landscape practices while treatments are usually conducted with little indication of the final distribution of the control agent. Molecular techniques offer the opportunity for insights into the lifestyle and assemblages of these cryptic insects that the management professional could integrate into a successful business model. Integration of molecular techniques into the practice of termite management will, however, involve a major shift in the zero tolerance-paradigm that has driven the industry for the past 70 years. The main promise of molecular techniques is their potential to provide a detailed view of termite population distributions and interactions in and around a structure. This information could be used to form the basis of a subterranean termite management mindset that moves beyond the current practice of detect-and-treat. Technologies available to the termite management industry in 2004 do not address issues common to effective Integrated Pest Management (IPM) practices especially identification of parameters that quantify economic injury levels. Molecular techniques currently employed in research programs have been used to describe the species composition and relatedness of termites collected at various points in and around structures using as few as 5-10 termites from each collection point. Molecular techniques will also eventually be able to address other questions important to developing termite IPM programs such as reproductive potential and measures of vigor for termites detected in and around structures. Such information can be employed by the management professional to map and access termite populations while employing a decision matrix based on proximity, relatedness and reproductive potential that identify termite populations as imminent, potential

or unlikely threats toward infestation given the construction, maintenance, and landscape practices at a particular account. The ability to categorize termite populations is the basis of any decision criteria scheme that would target specific groups of termites, or areas of a structure, for preventative treatment. The future of subterranean termite IPM looks bright under the molecular techniques umbrella. Yet, pitfalls confront the development and implementation of a management philosophy using molecular techniques that characterize termite populations. The most obvious is cost. The price tag for implementing an inspection program that elucidates the potential threats associated with yard termites starts with the increased labor costs involved in setting up and maintaining systems designed to identify termite populations. The cost of molecular techniques and analysis also presents additions to what the service provider must charge the consumer. Notwithstanding these hurdles the specter of accountability regarding the efficacy of a management practice on the part of the management professional as well as product registrants raises questions that must be addressed within the framework of their respective business models. Implementation of commercially viable subterranean termite IPM using molecular techniques requires overcoming a variety of economic and philosophical roadblocks. The goal of providing a cost effective and consumer-friendly service should be the end point of the collaboration between the research, regulation, production and service provider communities. Maintaining an open dialog between the aforementioned urban entomology partners is required to make meaningful subterranean termite IPM a reality.

TERMITES, FRIDAY SESSION

May 21, 2004

Regency Ballroom A

Moderator

Michael E. Scharf

Purdue University

West Lafayette, IN

TOXICITY AND REPELLENCY OF SESAME OIL AND SESAMOL ON FORMOSAN SUBTERRANEAN TERMITES (ISOPTERA: RHINOTERMITIDAE) IN TREATED SAND

Sanaa Ibrahim, S. Kambham, G. Henderson, and P. Jayasimha
Louisiana State University Agricultural Center
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Baton Rouge, LA 70803



TOXICITY AND REPELLENCY OF SESAME OIL AND SESAMOL ON FORMOSAN SUBTERRANEAN TERMITES (ISOPTERA: RHINOTERMITIDAE) IN TREATED SAND

S.A. Ibrahim, S. Kambham, G. Henderson* and P. Jayasimha
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Baton Rouge LA

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Introduction

- Of the estimated \$138 billion damage that all invasive species cause in the US each year, Formosan subterranean termites contribute \$1.5 billion.
- As some (or many) insecticides are harmful to people, we looked for the ones which are less toxic to humans.
- Our lab had previously tested several essential oils and natural products like patchouli oil, nootkatone and vetiver root oil.

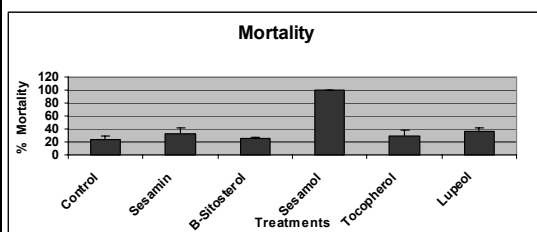
Sesame oil

- Naturally occurring product.
- Edible - used as a substitute for olive oil, hair oil, lubricant, and for soap.
- Sesame oil when mixed with fish oil, acts as an insecticide to eggs, larvae and nymphs as well as the adults of soft-bodied insects.
- Controls a wide range of insects including, but not limited to, chinch bug, spider mites, aphids, leaf-rollers, leaf miners, whiteflies, fungus gnats, thrips and some scale.

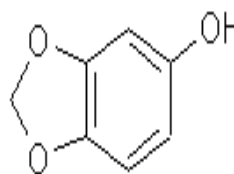
Preliminary Study

- Sitosterol, Sesamin, Sesamol, Tocopherol and Lupeol were previously found present in sesame seed oil and were tested.
- Each chemical was tested with 10 replicates; with 10 termites in each test tube.
- Sesamol gave the best results in this preliminary test. (See Fig.1).

Fig1: Percentages of worker mortality in response to 100 µg/cm² treated filter paper (no-choice tests)



Structure of Sesamol



3,4-methylenedioxyphenol

Materials

- Termites were collected from 3 different locations in Louisiana.
- Sesame oil (SO) was extracted in the lab from the unroasted sesame seeds that were purchased in local store.
- Sesamol was purchased from Sigma Aldrich Co.
- Hexane was used as solvent.

Methods

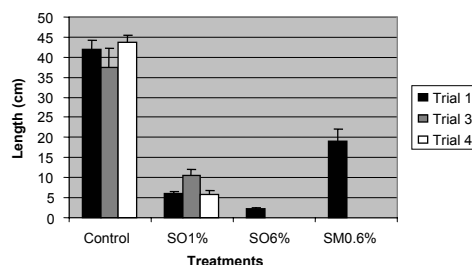
- 4 concentrations (Control, SO1%, SO6%, Sesamol 0.6%).
- 10 replicates for each concentration.
- For each replicate, 200 Workers and 8 Soldiers were used.
- In a 3 chambered container, untreated wet sand was placed in the 1st chamber into which termites were released.

(continued)

Methods

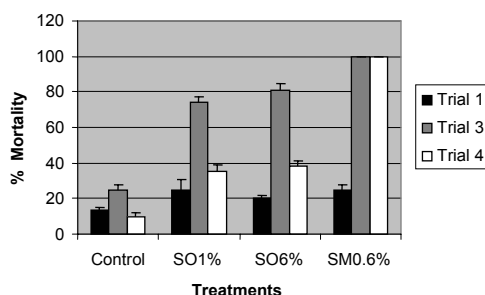
- 2nd chamber was filled with 110 g of treated wet sand.
- Whatman no 2 filter papers (4) were placed in the 3rd chamber.
- Tunnel lengths were measured for day 6,10,13 and 18 and on day 18, the number of living termites in each container was counted for each trial. (Trial 1 took place immediately after treatment and drying; Trial 2 = 1 mo post treatment (Ptt); Trial 3 = 2 mo Ptt and Trial 4 = 3 mo Ptt.)

Tunnel Lengths



Note: Trial 2 was omitted because of high mortality in control.

Mortality



Results

- Sesame oil at 1% and 6% Sesamol at 0.6% concentrations showed significant repellency for all months.
- Mortality was highest during the 2nd month (3rd trial) of testing.
- Sesamol remained highly effective in months 2 and 3.
- It is unclear why trial 1 had low mortality for all treatments.
- Sesamol is relatively inexpensive and shows promise as a natural alternative pesticide.

DEGRADATION OF TWO FORMULATIONS OF FIPRONIL APPLIED AS A RESIDUAL TERMITICIDE AT THIRTEEN STRUCTURES IN AUSTIN, TX

Harry N. Howell, Jr.¹ and Roger E. Gold²

Associate Research Scientist¹ and Professor and Chair of Urban and Structural Entomology,²

Center for Urban and Structural Entomology, Texas A&M University
College Station TX 77843-2475

Thirteen structures each with an active infestation of Subterranean termites (*Reticulitermes* sp. Isoptera: Rhinotermitidae) constructed on monolithic slab foundations in Austin TX were treated with fipronil in 1998. Six structures were treated with a 9.9% soluble concentrate @ 0.06% a.i. and seven structures were

treated with a 80% wettable granules @ 0.06% a.i. Samples of the treated soil around the structures were collected and analyzed for remaining fipronil at 1 week, 1 month, 6 months 12 months, 24 months, 36 months 48 months and 60 months post-treatment. The structures were inspected for subterranean termite activity at the same moments and the tenants were asked about any observed subterranean activity.

Results: No subsequent subterranean termite activity or damage was observed at any inspection. Analysis of the remaining fipronil in the soil around the perimeter of the structures showed a measurable decline in the concentration of fipronil in the soil. There was no difference in the degradation between the two formulations applied.

SEASONAL VARIATION OF JUVENILE HORMONE TITERS OF FORMOSAN TERMITE, *COPTOTERMES FORMOSANUS* (RHINOTERMITIDAE)

Yuxiu Liu¹, Lixin Mao¹, Gregg Henderson^{1*} and Roger A. Laine²
Department of Entomology, Louisiana State University Agricultural Center,
Louisiana Agricultural Experimental Station, Baton Rouge LA 70803.

Seasonal Variation of Juvenile Hormone Titers of Formosan Termite, *Coptotermes formosanus* (Rhinotermitidae)

Yuxiu Liu, Lixin Mao, Gregg Henderson and Roger A. Laine
Department of Entomology, Louisiana State University Agricultural Center,
Louisiana Agricultural Experimental Station, Baton Rouge LA 70803.





Introduction

- 1. What are the mechanisms that regulate soldier development?
- 1) Endocrinological level studies revealed that soldier production required high levels of JH, produced by the corpora allate (CA).
- 2) Social level studies showed that the presence of reproductives favored soldier formation, while the presence of other soldiers inhibits it.
- 3) Abiotic extrinsic factors such as temperature and nutrition also affect soldier differentiation.

• 2. What regulates termite soldier proportions to vary seasonally with changing environmental conditions? Many other insects also demonstrate seasonal changes in endocrine and behavioral status (i.e. JH seasonal variation in Honey bees).

• 3. The objective of this study was to get the picture of seasonal variation of JH titers from Formosan termite workers and soldiers.

• Uniqueness of this study:

• 1) Termites were collected from cypress trees in Lake Charles. The water barrier ensured that seasonal termite collections were from the same colonies, **free from inter-colony contamination**, which therefore ensures the precision and accuracy of JH from specific colonies.

• 2). This ecosystem provided us with colonies that were **isolated to a single food source**.

• 3). Quantitative evaluations of JH in termite species were conducted for the first time.

Salt Water Dam of Lake Charles



Materials and methods

1. Termite collection and sampling

- Foraging populations were collected from cypress trees (*Toxodium distichum* (L.) Rich.) by using corrugated cardboard rolls in a polyvinyl chloride (PVC) tube inserted into the trees. Five colonies were collected once a month from April 2003 through May 2004.



2. Preparation of whole body extracts

The technique of termite whole body extraction was similar to one used by Bergot et al (1981) and Shu et al (1997).

3. Synthesis of internal standard JH-IIIIEE (JH-III ethyl ester)

According to Mori et al (1973), JH-IIIIEE was prepared from JH-III using a mild transesterification method.

4. Measurement of JH titers

Measurement of JH content was conducted according to Bergot et al (1981) and modified by Shu (1997) and Cole et al (2002).

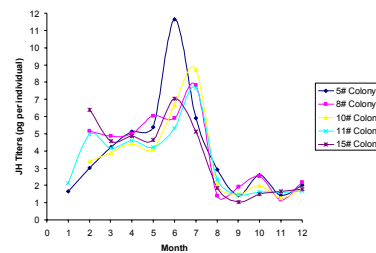
The samples were applied onto a Trace 2000 (Thermo Finnigan) GC-MS in positive EI mode with selected ion monitoring. JH titers are expressed as pictogram per individual.

Results

Seasonal variation of soldier JH titers

- Seasonal changes in soldier JH titers throughout 12 months revealed differences among 5 colonies. There are, however, several patterns common to all colonies (Figure 1).
- Soldier JH climbed a colony-specific peak level in June or July.
- A sharp drop of soldier JH was subsequently observed in August from each colony.
- During fall and winter months, i.e. from September through December, soldier JH persisted at a low level for five colonies.
- Due to the cold weather in January, foraging termites were collected only from two colonies.
- From February through May, soldier JH levels increased to a broad plateau.

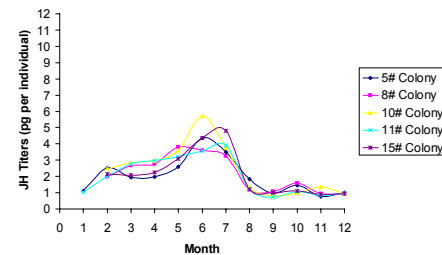
Seasonal Variation of Soldier JH Titers



Seasonal variation of worker JH titers

- Worker JH content was less than that of soldier from the same colony.
- The profile of seasonal variation of worker JH titers went the similar trend as that of soldier JH titers. Low level of worker JH titers was observed from August until next January. They began to increase in February and kept a high level through April. Worker JH titers rose at peak level in May (8# colony) or June (5#, 10#, 11# and 15# colony).

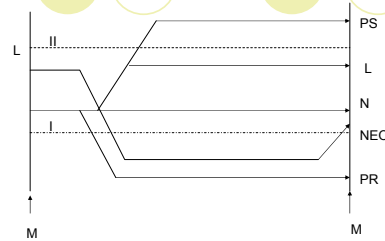
Seasonal Variation of Worker JH Titers



Discussion

- 1. This study demonstrates that natural environment changes are related to endocrine changes in termite workers and soldiers that are known to mediate caste differentiation.
- 2. As suggested by Henderson (1998), a specific JH titer is associated with each termite caste and JH titers in colony systems are related to caste differentiation.

Figure from Henderson (1998). The likelihood of termite larvae (L) and nymphs (N) to molt into a presoldier (PS), primary reproductive (PR), or neotenic reproductive (NEO), when JH hemolymph titer reaches a high threshold (II) or low threshold (I). M=the molt cycle.



- 3. High level of JH from February through July might generate numerous soldiers during this season. This ability should be advantageous to the colony, because soldiers typically stand guard around flight exit holes where predation can be high (Wilson, 1971).
- 4. In the meantime, primary and neotenic reproductives are also produced during this season. We suggested here that soldiers probably absorb JH from the system and that white soldier might act as JH "sponges" that regulates JH titers in colony system.

- 5. The mechanisms of soldier-intake-JH may involve CA absorption, proteins that bind-up JH, esterases that breakdown the hormone, or combinations of all three.
- 6. The mechanisms underlying the observed seasonal changes in JH are not clear.
- Questions on whether and to what extent, if any, the temperature, nutrition, colony size and age, existing soldier ratios influence variation of JH titers need to be further investigated.

Thank you very much!



EFFECTS OF MULTIPLE GENERATIONS OF *METARHIZIUM ANISOPLIAE* ON SUBTERRANEAN TERMITE FEEDING AND MORTALITY

Kimberly M. Engler, and Roger E. Gold
Department of Entomology, Texas A&M University

This research evaluated the attractancy and mortality caused by *Metarhizium anisopliae* on two species of subterranean termites, *Reticulitermes flavipes* (Kollar) and *Coptotermes formosanus* Shiraki. This work was done by testing the mycelium mat matrix of *M. anisopliae* cultured on rice or corn in a glass tube bioassay system. The tunneling distances of *R. flavipes* and *C. formosanus*, when exposed to aged strains of *M. anisopliae*, were measured along with the mortality caused by the fungus to populations of the termites. In addition, comparisons were made to determine if *R. flavipes* termites were attracted to ethanol extracts of the mycelium of *M. anisopliae* (X-5), or a commercial preferred feeding product (Summon®). The extracts and the Summon® disks were tested in the laboratory using glass plate bioassays, and in the field using commercial termite monitors containing each of the treatments individually.

The results with attractancy and mortality varied with age and generation of *M. anisopliae* mycelia, but all treatments were more attractive and caused more mortality than the controls. When presented with choices, both *R. flavipes* and *C. formosanus* showed preference to both the mycelium and the extract forms of *M. anisopliae*. The 1:1000 dilution of *M. anisopliae* extract (X-5) was strongly preferred over the other treatments, and all of the dilutions were preferred over the Summon® and ethanol (40%) treated disks in the laboratory. An analysis of the consumption of test cellulose matrix showed that Summon® did not attract termites, but it was a preferred food source. When the undiluted ethanol extract of *M. anisopliae* was tested in the field, there were more termite visits to the ethanol extract of *M. anisopliae* (X-5) treated monitors stations, and the fewest termite visits were observed in the monitors containing the untreated fiber pulp disks.

MOLECULAR AND BIOCHEMICAL STUDIES OF CASTE DIFFERENTIATION IN THE EASTERN SUBTERRANEAN TERMITE *RETICULITERMES FLAVIPES*

Michael E. Scharf, Catina R. Ratliff, Xuguo Zhou, Dancia Wu-Scharf,
Barry R. Pittendrigh¹, and Gary W. Bennett
Center for Urban and Industrial Pest Management, ¹ Department of Entomology
Purdue University, West Lafayette, IN 47907-2089

In lower termites, including *Reticulitermes*, juvenile hormone (JH) serves as a primer pheromone. Primer pheromones are broadly defined as chemical messengers that (1) can be passed between conspecific individuals, and which (2) trigger physiological responses in recipients. In lower termite colonies, JH suppresses differentiation of nymphs (*i.e.*, immature reproductives) and various reproductive phenotypes at intermediate titers, while it induces juvenile soldier differentiation when it occurs at excessively high titers (reviewed by Henderson 1998). It is only when JH suppression is lifted, and JH titers drop below critical thresholds, that nymphs differentiate. Nymphs proceed through several instars before they emerge as adult reproductives, while a single presoldier (*i.e.*, a juvenile soldier precursor stage) instar is directly followed by the emergence of the fully developed soldier. The differentiation of the soldier caste in response to JH is in direct contrast to the *status quo* role of JH in maintaining immature features in all other non-social insects (Henderson 1998, Gilbert *et al.* 2000). It also appears that the soldier caste may be involved in lowering intra-colony JH titers, thus enabling reproductive differentiation. Therefore, in *Reticulitermes* and other lower termites, JH appears centrally important as a physiological regulator / inducer of caste differentiation.

Over the past three years, our laboratory has been engaged in efforts to identify genes and proteins involved in caste differentiation and caste-associated physiology in U.S. *Reticulitermes* species. This talk will focus specifically on our efforts to develop a deeper understanding of soldier caste differentiation in *R. flavipes*. Our approach has three components: (1) caste-differentiation assays that employ exposure by termites to juvenile hormone III (JHIII), (2) biochemical investigations that examine hemolymph protein composition between castes and developmental stages and in response to JHIII treatment, and (3) molecular investigations that employ cDNA arrays and quantitative PCR to examine gene expression patterns between castes and in response to various experimental assay conditions.

In previous molecular-genomic studies comparing *R. flavipes* castes and developmental stages, we identified enhanced expression of two key genes related to JH physiology: hexamerin and vitellogenin. Hexamerin gene transcripts show elevated expression in developing nymphs, while vitellogenin shows unexpectedly elevated expression in presoldiers. Our findings for

vitellogenin gene expression in presoldiers are interesting, as vitellogenin has primarily been considered as an egg yolk protein that is produced by reproductively competent females for packaging into oocytes. However, an understanding is emerging that insect vitellogenins also serve as JH and ecdysone-binding carrier proteins (Nation 2002). In this respect, we are testing the hypothesis that vitellogenin and hexamerin proteins play roles in *Reticulitermes* caste differentiation processes by serving as hemolymph JH binding proteins.

In this presentation, we report on our studies using JHIII to induce presoldier differentiation from *R. flavipes* workers. We then investigated changes in (1) hemolymph protein composition and (2) expression levels of hexamerin and vitellogenin gene transcripts in presoldiers and undifferentiated workers sampled over the course of assays.

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TERMITE BAITING AND MONITORING: A CENTRAL COMPONENT OF AREA-WIDE IPM

Robert R. Setter
The University of Iowa, Facilities Services Group

The eastern subterranean termite *Reticulitermes flavipes* Kollar, has been an ongoing and wide-spread problem on the University of Iowa main campus. In 1995 facilities staff stopped traditional liquid chemical insecticide applications due to the need for annual reapplication, continued resurgence of termite infestations, and community-wide concern regarding this process. A termite monitoring and baiting program was initiated utilizing the Sentricon® Colony Elimination System. Since 1995 the Sentricon® network on campus has expanded to include in excess of 3500 stations around 70 buildings that total in excess of 74,000 linear feet of perimeter. Except for the chemical pre-treatment of five new buildings, Sentricon® has remained the sole termite control tool on campus since 1995. Monitoring efforts have expanded to include detailed building inspections and grounds surveys. Survey results reveal that 80% of the buildings surveyed have had termite activity inside. Thriving termite populations have been located throughout landscaped areas between buildings. The long-term monitoring and mapping of termite populations finally lead to an opportunity for area wide suppression in the summer/fall of 2003. In addition to the extensive survey, detection and baiting efforts, indirect controls such as physical barriers and altered storage techniques have been implemented whenever possible. Combined with extensive outreach to all sectors of the campus community, the ongoing termite control and prevention efforts have substantially reduced the damage to campus infrastructure and archives.

However, the University of Iowa campus contains substantial areas of termite refuge including wooded areas, parks and railroad rights-of-way. Further termite populations can be found within easy immigration distance in the urban areas that border the main campus. Maintaining the survey and detection program into the future will provide the opportunity for early warning when termite populations immigrate back into previously infested areas. Continued implementation of physical controls and altered storage techniques through the normal course of construction, renovation and relocation will provide cost-effective prevention of future termite infestations. The termite control program at The University of Iowa has continued to grow and evolve to the point where all the components of a traditional IPM program (monitoring, direct control, indirect control, outreach) are providing significant contributions to the mitigation of termite damage.

CRUSHED LIMESTONE AGGREGATE AS A PHYSICAL BARRIER TO THE EASTERN SUBTERRANEAN TERMITE *RETICULITERMES* *FLA VIPES* (ISOPTERA:RHINOTERMITIDAE)

Robert R. Setter¹ and Mehmet S. Serdaroglu²

¹The University of Iowa, Facilities Services Group

²The University of Iowa, College of Engineering

The use of aggregate with specifically sized proportions has become an effective tool for preventing the infestation new construction by subterranean termites. While both Basaltic Termite Barrier and Granitgard have attained substantial market presence in Hawaii and Australia respectively, similar products have not found wide-spread use in other locations. Due to the high cost of hauling aggregate, one of the hurdles to establishing this technology in new locations is developing a suitable source of material within a reasonable distance to the marketplace. Through collaboration with a local quarry in Iowa City, Iowa, crushed limestone from specific source beds has been assessed for suitability in use as a physical barrier to the eastern subterranean termite *Reticulitermes flavipes* Kollar. A combination of lab and field trials indicate various gradations of crushed limestone with $\geq 88\%$ of the particles between 1.0 and 3.35 mm in size effectively prevent termite tunneling.

Due to the need to place this material around building foundations, several questions were raised by project architects and engineers. In response to these questions the physical and structural properties of the crushed limestone aggregate were determined. Results indicate this material is suitable for use not only as a termite barrier, but as a structural and functional component of a buildings' foundation. To enhance structural and mechanical performance, the gradation of the aggregate was optimized to be as coarse as possible while retaining termite barrier qualities. In addition to being an effective termite barrier, with the proper design and installation a 6" layer of the specified crushed limestone aggregate can provide drainage, thermal insulation, structural support and radon mitigation to the deep foundations required on institutional and residential buildings in the Mid-western United States. The material thus has a multi-functional nature, making installation more cost effective than if used solely as a termite barrier. Compatible with termite baiting techniques, this multi-functional use of aggregate in building foundations will find favor with the United States Environmental Protection Agencies' 'Safe Buildings' initiative.

ANTS

Regency Ballroom B

Moderator
Janet Kintz-Early
Nisus Corporation
Rockford, TN

IMPORTED RED FIRE ANT CONTROL WITH TOPCHOICE™ BAIT AND GRANULE PRODUCTS

Michael Chapman
Bayer Environmental Science

The Imported Red Fire Ant (*Solenopsis invicta*) is a major pest and health threat throughout its range within the United States. Since its introduction into the United States various methods and products have been used to control and/or try to eradicate this ant with varying success. TopChoice granules and baits labeled for Fire Ants were registered in "1998". TopChoice bait is formulated at 0.00015% and the granules are formulated at 0.0143%. Both the bait and the granule may provide up to 1 year of control with a single application. When applied at the same time they provide quicker control than using a two-step treatment. 90% control can be obtained within 9 -12 weeks. The amount of rainfall appears to affect the reduction in mounds with the rainfall above 16 inches providing more reduction.

BORIC ACID GRANULAR BAIT EFFICACY TESTS ON COMMON PEST ANT SPECIES

Janet Kintz-Early¹, Reed L. Kirkland², Ron Cardoza², Joseph Jonovich³ and Jeff
Lloyd¹
Nisus Corporation¹, Bio Research², Horticare³

A boric acid granular bait (available commercially as Niban G granular bait) was evaluated in a laboratory to assess bait attractiveness and mortality to several common household pest ants. The following ant species were evaluated:

argentine ants (*Linepithema humile*), southern fire ants (*Solenopsis xyloni*), pavement ants (*Tetramorium caespitum*), pharaoh ants (*Monomorium pharaonis*) and carpenter ants (*Camponotus modoc*). Argentine ant mortality was also evaluated with a weathered boric acid bait (available commercially as Niban G granular bait). Carpenter ant attraction to the bait and mortality was evaluated with two different boric acid granular baits (available commercially as Niban (Brand A) and Intice (Brand B)). The red imported fire ant (*Solenopsis invicta*) study was conducted to evaluate the efficacy of a boric acid bait (available commercially as Niban G granular bait) as a broadcast bait and as an individual mound treatment using a hydramethylnon granular bait (available commercially as Amdro) as an industry standard.

It was found that the boric acid granular bait was effective in killing argentine ants and pavement ants within a 2-wk period; however mortality occurred significantly faster when no alternative food sources were available. It was also effective in killing southern fire ants within a 2-wk period, even when alternative food sources were available. The boric acid granular bait was moderately effective in killing pharaoh ants, but only when no alternative food source was available. Argentine ant mortality was significantly higher when provided with a boric acid bait exposed to 2.5 inches of rain or a boric acid bait exposed to 4 inches of rain than in the bait containing no boric acid. In bait attractiveness tests, carpenter ants removed two times more of Brand A than Brand B at the end of the 14-d study. Carpenter ant mortality was significantly greater with Brand A than with Brand B at 7-d and at 14-d. In addition, there was no statistical difference in mortality between ants fed Brand B and ants provided only water. In the red imported fire ant tests, the broadcast boric acid bait did not perform as well as the broadcast hydramethylnon treatment or the boric acid individual mound treatment. The boric acid bait, when applied as an individual mound treatment, performed better than the hydramethylnon broadcast treatment, eliminating 65% of red imported fire ant populations as opposed to 45% of the ant populations in the hydramethylnon plot.

These results suggest the tested boric acid granular bait was effective against all ant species tested, although with pharaoh ants it would be important to remove alternative food sources (which is good commercial practice anyway). The results would also suggest that the Niban G boric acid granular bait was superior to another apparently similar boric acid granular bait product. Finally, a field study suggests a boric acid bait is good option for red imported fire ant control and should be considered for use in a fire ant management program.

EFFICACY OF TERMIDOR AND PHANTOM ON TROPICAL ANT COMPLEX IN SANTA ISABEL, PUERTO RICO

Bob Hickman and Don Bieman,
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Puerto Rico's tropical climate offers year round conditions suitable for proliferation of several pest ant species including ghost ants (*Tapinoma melanocephalum*), crazy ants (*Paratrechina longicornis*) and destructive trailing ants (*Monomorium destructor*). Control of these pest ants in and around small single family homes was evaluated using four treatments: 1) Termidor SC (alone) as an outdoor perimeter treatment; 2) Phantom (alone) as an indoor C&C/void treatment; 3) Termidor + Phantom (combination) treatments above; 4) Untreated controls. Ant activity, prior to treatment and up to 59 days post treatment, was determined by counting numbers of ants on small absorbent cotton pads saturated in sucrose solution placed on windowsills of homes. In addition, a survey of the homeowner's assessment of control and an indoor inspection for ants by a technician was conducted at 2 weeks after treatment. The Termidor exterior treatments at 0.06% with indoor Phantom applications at 0.50% provided better overall ant control than the separate treatments of Termidor applied as an exterior treatment or Phantom applied as an indoor treatment.

SUMMARY OF FIELD TRIALS THAT DEMONSTRATE THE EFFICACY OF TERMIDOR IN THE CONTROL OF SELECTED ANT SPECIES

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Numerous surveys have indicated that ants are now the #1 class of pests in our industry. Many new products and tools have been developed over the past decade to help Pest Management Professionals (PMPs) control these pests. The recent development of newer non-repellent insecticides has provided the pest control industry with a different concept in controlling ants. Fipronil (active ingredient in Termidor SC and WG Termiticide/Insecticide) has shown promise as an excellent ant control agent in lab studies. Therefore, the manufacturer initiated a series of field trials to determine the efficacy of Termidor against popular urban pest ant species. Field data were collected that showed excellent control (100% control at 4 MAT) of carpenter ant field populations in the Northwest US using a single exterior Termidor treatment. A single exterior perimeter Termidor application provided between 90-100% control (17 WAT) of odorous house ant populations in Tennessee. Pavement ant populations were controlled (90-100%) for up to 20 WAT using an exterior perimeter Termidor

application in Indiana. Crazy ants and Acrobat ants were controlled (100%) through 10 weeks and 16 weeks post single treatment in Texas, respectively. These data have been submitted to the regulatory authorities to amend the Termidor label to include these ants on the label. This should provide PMPs with another tool to help control ants.

ODOROUS HOUSE ANT SPRING AND SUMMER COLONY COMPOSITION

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Odorous house ant colonies were collected using two methods during spring and summer to find an efficient collection method and to determine colony composition of field-collected colonies. Odorous house ant (OHA) colonies were collected by shoveling/scooping a 0.3m x 0.5m section of mulch/pine straw or by allowing ants to move between two 0.3m x 0.5m sheets of tin. The number of workers, queens, eggs, larvae <2mm, larvae>2mm, and pupae; worker mass and brood area (cm²) were calculated for 7 colonies collected using each method in spring and summer. Data (number, mass, area or ratios of castes and stages) were analyzed using SAS 9.0 PROC MIXED with a completely randomized design, and collection method and season as fixed variables. No significant differences were found in either spring or summer between collection methods for six of seven colony variables. The tin collection method was much easier to use than the mulch/pine straw method due to the increased time needed to separate ants and brood from the mulch/pine straw. Season significantly affected 4 of 7 colony composition variables. Significantly more workers, eggs and pupae and significantly less larvae >2 mm, assumed to be sexual larvae, were found in the summer-collected nests. The composition of a field-collected OHA colony appears to be roughly 150 workers to each queen and 200 workers to every square centimeter of brood. According to the field results, we will adjust future lab bait bioassays to include 400 workers, 2 cm² brood and 3 queens.

ACTIVITIES OF FIPRONIL, CHLORFENAPYR, AND BIFENTHRIN AGAINST ARGENTINE ANTS

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The activities of fipronil (Termidor SC), chlorfenapyr (Phantom), and bifenthrin (Talstar Flowable) against the Argentine ant, *Linepithema humile* (Mayr), were

tested in laboratory assays. Chemicals were evaluated for topical toxicity, mobility impairment, horizontal activity, and barrier effects.

For each chemical, ants were topically treated by spraying ten groups of twenty ants and transferring the ants to dry containers. Mortality was recorded at 30-minute intervals for four hours (Figure 1). Treatment with bifenthrin resulted in near 100% mortality within 30 minutes. Mortality was slightly delayed for both chlorfenapyr and fipronil; however, both caused approximately 90% mortality after four hours.

For mobility tests, ants were topically treated in cohorts of 100, then separated into groups of ten ants, replicating with ten treated cohorts. At 30-minute intervals for 2 hours, ten ants were placed inside 14-cm diameter circles drawn on paper. Ants remaining inside the circles after two minutes were counted (Figure 2). All bifenthrin-treated ants were immobilized within the first 30 minutes. The number of ants remaining inside the circles was 62% for chlorfenapyr and 18% for fipronil 2h after treatment.

Horizontal activity was evaluated by topically treating 5, 10, or 20% of the ants in a group of 300. Treated ants were allowed to die, then were placed on plastic disks in boxes containing untreated nestmates. Since ants readily handle cadavers, this method allows contact between treated and untreated individuals while preventing contamination of the arena floor. Ants were incubated at 10°, 20°, or 30°C for 3 days before determining mortality of untreated ants (Figures 3-5). There were six replicates for each treatment combination. For bifenthrin, the number of treated ants had a significant effect on Argentine ant mortality. No difference was seen among temperatures. For chlorfenapyr, both temperature and percentage of treated ants were significant. For both bifenthrin and chlorfenapyr, no treatment had more than 30% mortality of untreated ants. In fipronil trials, mortality of untreated ants was affected by both temperature and percentage of treated ants. The interaction of the two factors was also significant, with mortality increasing with percentage of treated ants at 10° and 30°, but not at 20. Mortality at 20° and 30° was higher than in the bifenthrin and chlorfenapyr treatments.

Barrier tests were conducted to evaluate the combined effects of repellency and recruitment inhibition. A 3-box configuration was used: a center nest chamber connected by paper bridges to two foraging arenas. Bridges were 15" x 2" strips cut from file folders, with the center 4" x 2" section treated with one of the insecticides or water. Cinnamaldehyde (Cinnamite) was used as a positive (repellent) control. Foraging arenas contained a nesting cell, food, and water. Ants were starved for 2 days, then 300 were placed in the nest chamber with no food or water. Tests were replicated ten times. After 24 hours, bifenthrin and cinnamaldehyde treatments had fewer ants than their paired control bridges, while more ants crossed the fipronil-treated bridges.

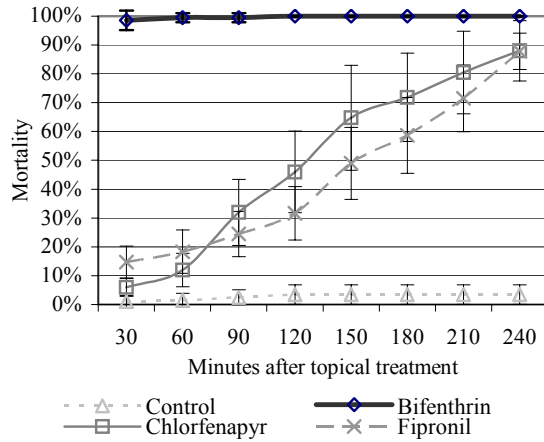


Figure 1. Mortality (mean \pm SE) after topical treatment.

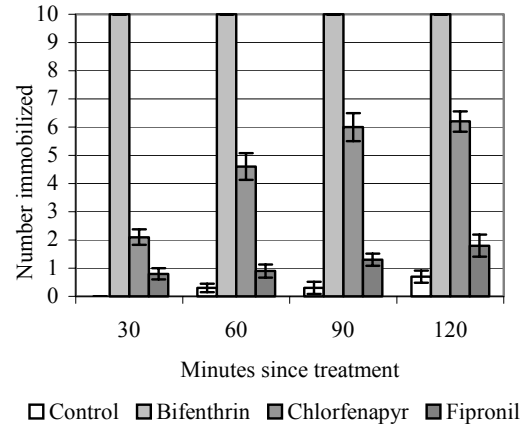


Figure 2. Mobility impairment after topical treatment.

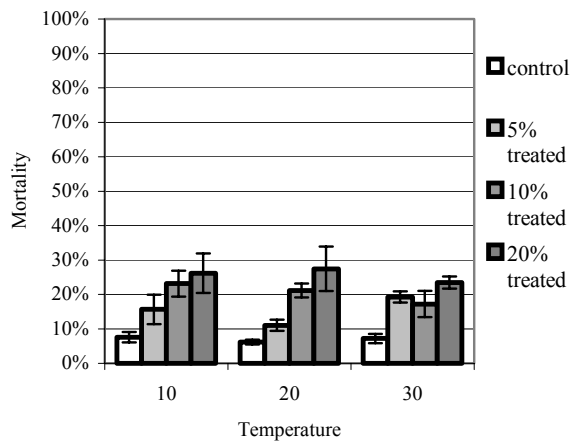


Figure 3. Mortality of untreated ants exposed to bifenthrin-treated nestmates.

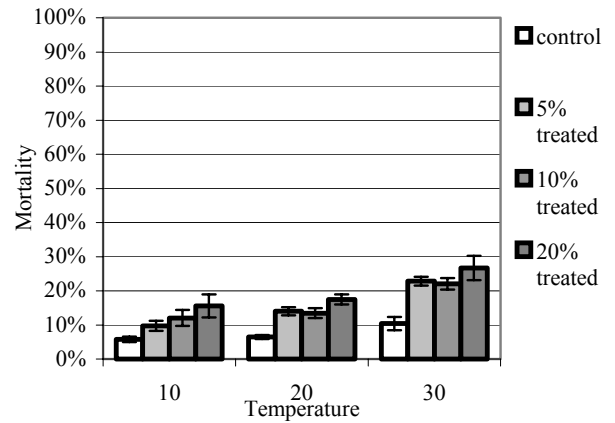


Figure 4. Mortality of untreated ants exposed to chlorfenapyr-treated nestmates.

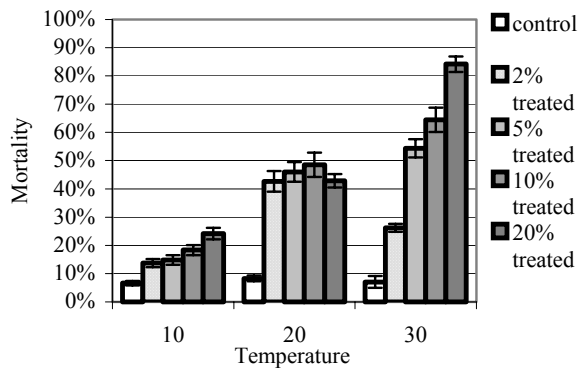


Figure 5. Mortality of untreated ants exposed to fipronil-treated nestmates.

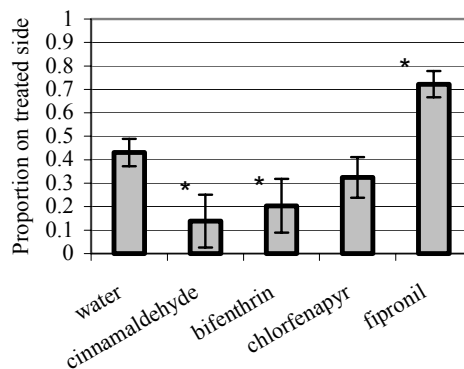


Figure 6. Proportion of ants on insecticide treated side in choice test. *number of ants different from paired control ($p < 0.05$)

THE RESURRECTION OF THE GERMAN COCKROACH

Regency Ballroom B

Moderator
Shripat Kamble
University of Nebraska
Lincoln, NE

EVALUATION OF GERMAN COCKROACH (*BLATTELLA GERMANICA* (L.) (DICTYOPTERA: BLATTELLIDAE) BEHAVIORAL AVOIDANCE OF GEL BAIT FORMULATIONS

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German cockroaches were evaluated in the laboratory for behavioral avoidance of gel bait formulations. The Bubba strain German cockroach was collected from a large state government cafeteria facility in Maryland. The pest management company for this facility was having difficulty controlling the infestation with gel baits. The Saginaw strain German cockroach was collected from a single family home in Saginaw MI where the pest control company was receiving complaints after using MaxForce FC and hydramethylnon gel bait formulations. These two strains were suspected to be averse to gel bait formulations. To determine if the Bubba and Saginaw strains were truly averse to gel baits, bait consumption and subsequent mortality was compared in no choice tests with other German cockroach strains: a known susceptible laboratory strain [Virginia Polytechnic and State University (VPI)] and a field collected strain (Jeff Wilson) known to be cyfluthrin resistant.

Evaluations to determine baseline consumption (mg/ 2 h) of dry dog food for each strain indicated that there were no strain related differences in consumption (Table 1).

Strain	n	Mean Consumption (mg) + SEM	F-value	P-value
VPI	12	36.3 \pm 6.9a	1.3	0.30
Bubba	12	28.6 \pm 2.1a		
Saginaw	4	29.8 \pm 4.4a		
Jeff Wilson	12	25.0 \pm 3.1a		

* Means followed by the same letter were not significantly different.

Preliminary data: Cockroach consumption (mg/2 h) of baits determined that there were strain related differences in the consumption of gel bait formulations.

Mean Consumption (mg) \pm SEM by Cockroach Strain ¹					
Gel Bait	Bubba	VPI	Saginaw	Jeff Wilson	P-value
Avert Formula 3	29.6 \pm 3.3b	173.1 \pm 12.0a	--	---	<0.001
MaxForce Hydramethylnon	17.3 \pm 7.4b	56.0 \pm 14.8a	5.5 \pm 14.8b	---	< 0.057
MaxForce FC	6.0b	79.3 \pm 4.5a	26.0 \pm 0b	75.0 \pm 7.0a	< 0.002
PreEmpt	17.0 \pm 4.6a	18.7 \pm 2.3a	--	9.0 \pm 6.0a	0.350

* Means followed by the same letter were not significantly different.

¹Replications by strain range between 1 (Bubba and Saginaw fed MaxForce FC) and 10.

Preliminary data: Percent cockroach mortality (30 adult males total) indicated that there were strain related differences after 2 h exposure to gel bait formulations.

Percent Mortality (24h or 48h) \pm SEM by Cockroach Strain					
Gel Bait	Bubba	VPI	Saginaw	Jeff Wilson	P-value
Avert Formula 3 ²	19 \pm 0.03b	83 \pm 0.06a	--	---	< 0.001
MaxForce Hydramethylnon ³	28 \pm 0.04b	94 \pm 0.01a	17.0 \pm 0.0b	---	< 0.001
MaxForce FC ²	20.0b	99 \pm 0.01a	3.3 \pm 0.0c	93.0 \pm 0.07a	< 0.001
PreEmpt ³	46 \pm 0.04b	77 \pm 0.1a	--	33 \pm 0.07b	0.023

* Means followed by the same letter were not significantly different.

¹ Replications by strain range between 1 (Bubba and Saginaw fed MaxForce FC) and 10.

² % Mortality recorded after 24 h.

³ %Mortality recorded after 48 h.

From the preliminary data we were able to conclude that the Bubba and Saginaw strains consumed less of the gel bait formulations than the other two strains. However, consumption of the PreEmpt gel bait was not significantly different for any of the strains tested. Because of the reduced consumption, mortality of the Bubba and Saginaw strains was also significantly lower than that of the VPI strain for all gel bait formulations tested. However, cockroach mortality for the Bubba and Jeff Wilson strain when exposed to PreEmpt bait was not significantly different.

In performing these experiments we made several observations. The first was that the Bubba and Saginaw strain cockroaches would contact the baits even though they did not consume them. Immediately after the bait was put into the test arenas the cockroaches would leave the harborage, wave their antennae, and search for the bait. Once the cockroaches had located the bait they would contact it with the palps. The antennae would continue to wave as the cockroaches made multiple contacts with the mouthparts on the bait. However, after several “tastes” the cockroaches would walk away. These behaviors suggest that the antennal receptors of the Bubba strain recognize the gel bait as a potential food resource. However, the receptors on the palps do not. Our observations indicate that it is the reduced palatability of gel formulations, as opposed to repellency or cockroach learned behaviors (1), that is causing the bait avoidance and increased survivorship of the Bubba and Saginaw strain German cockroaches.

1 Rust, M. K., J. M. Owens and D. A. Reiersen. 1996. Understanding and controlling the German cockroach. Oxford University Press, New York. 430 pp.

THE BAIT AVERSE GERMAN COCKROACH (*BLATTELLA GERMANICA*): WHERE ARE THEY? AND HOW DO THEY REACT TO COMMERCIALLY AVAILABLE BAITS?

Tom Macom and Nonggang Bao
Bayer Environmental Science

Bait aversion issues have recently resurged years after the glucose aversion problems were discovered and corrected in the early 1990s. Observations of poor acceptance of commercial cockroach bait gels and control failures were reported by PMP'S in 1999. In response to the increased complaints of German cockroach control failures in the field, Maxforce[®] researchers started to collect these cockroaches in 2000 and tested their responses to commercially available baits. Test results confirmed a new bait aversion exists in German cockroach populations across the Continental United States and that the degree (intensity) varies among geographic areas. The results further suggested rotation of the commercially available gel baits did not solve these control issues. After several years of study, Bayer Environmental Science developed over 50 experimental

gel formulae were developed and tested. As a result, a new gel bait formulation (Maxforce Select) was finally selected for commercialization after extensive laboratory and field trials.

Maxforce is a registered trademark of Bayer AG

BAIT AVERSION AND BAIT RESISTANCE IN GERMAN COCKROACH, *BLATTELLA GERMANICA* (DICTYOPTERA: BLATTELLIDAE)

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Similar to insecticide resistance, bait resistance is the ability in a strain of insects to tolerate an insecticidal bait treatment which would be lethal to the majority of individuals in a normal population of the same species. Insecticide resistance and bait aversion are the two potential reasons for bait resistance. Our study demonstrates that while many baits are performing well against lab susceptible Orlando Normal strain, many field collected strains of German cockroaches are resistant to cockroach baits. Bait resistance to gel baits is much higher than resistance to station baits. Bait selection pressure may increase the level of bait resistance in some strains but may not have much effect on other strains. All bait resistant strains show reduced consumption of toxic baits as compare to lab diet indicating that bait aversion is the major contributor to bait resistance. However, insecticide resistance also contributes to bait resistance in some strains. The specific bait aversion mechanism is currently under investigation. It is likely the bait aversion is caused by more than one ingredients acting together and different strains may have different bait aversion mechanisms.

INSECTICIDE RESISTANCE IN THE GERMAN COCKROACH: WHAT HAVE WE LEARNED IN THE PAST DECADE AND HOW CAN WE APPLY IT TO CURRENT MANAGEMENT PROGRAMS?

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Insecticide resistance in the German cockroach has a long history dating back more than 45 years. Insecticide resistance in this species has been documented to every neurotoxic insecticide class and some respiratory toxins. Furthermore, resistance has been documented to products formulated as residual contact insecticides, flushing agents and bait products. Thus, recent incidences of gel

bait aversion resistance are but one example from a long history of remarkable adaptation by this pest.

This presentation reviews cockroach resistance research from the past decade. The goal of this presentation is to highlight resistance-associated phenomena that researchers should be aware of when investigating insecticide resistance and its management, in the present-day, as well as in the future. Specific topics covered in this talk will include: (1) a brief history of resistance pre- and post-1990, (2) a review of the types of resistance and resistance mechanisms that have been documented in the German cockroach to date, (3) well-researched bioassay methods for the documentation and quantification of resistance, (4) rates of resistance evolution, and (5) viable approaches to resistance management in urban settings.

FIELD INCIDENCE OF GEL BAIT AVERSION IN GERMAN COCKROACHES (*BLATTELLA GERMANICA*), A RECENT HISTORY

Joe Barile, Nonggang Bao, Gary Braness, John Paige, Mike Chapman
Bayer Environmental Science

Baits have become the dominant formulation of choice for US PMPs when performing cockroach service (Clorox 2000 data). Among bait types, cockroach bait gels have become the preferred formulation among professionals. Given the historical success of bait gels against German cockroaches (*Blattella germanica*) the reporting of control difficulties in field populations was a matter of great concern to the industry.

Observations of poor acceptance of commercial cockroach bait gels were reported by PMPs in 1999. These initial reports were of single instances and locations were scattered in three distinct geographic locations: South Florida; the Dallas-Fort Worth Metroplex; and the New York City-North New Jersey Metroplex.

On-site visits were made with cooperating PMPs to evaluate bait acceptance and PMP baiting practices. In many cases poor bait performance was the result of applicator inefficiency (i.e. bait volume applied). Where feeding aversion was observed insects were collected and sent to our laboratory to establish field colonies.

Reports of bait aversion coincided very closely with the introduction of fipronil as the active ingredient in Maxforce brand cockroach bait gel. Additionally, a report of potential fipronil resistance in field populations of German cockroaches was presented late in 1999 (Holbrook & Schal, North Carolina State University).

However, in laboratory trials both lab and field strains of cockroaches were killed when directly exposed to label rates of fipronil and other cockroach bait gel active ingredients.

Substituting original Maxforce cockroach bait gel, with hydramethylnon active ingredient, resulted in an improved, but not expected feeding response. Additional field sites were treated with competitive brands of cockroach bait gels. In all sites, although the initial feeding response improved, aversion behavior was demonstrated usually within a few weeks. Our conclusion based on these observations as well as laboratory trials is that this behavior is common to all commercially available cockroach bait gels and that rotation of products based on active ingredients and/or brand(s) is ineffective.

Locations where populations of cockroaches demonstrated this aberrant behavior had the following common characteristics: most were commercial food service accounts; floor level sanitation was poor; Heavy reliance (in many cases total reliance) on cockroach bait gels for control.

The aberrant cockroach behavior being reported in 1999 was not the first time that PMPs were faced with bait aversion in German cockroaches. In 1990 cockroach gel bait aversion was observed and reported to Maxforce originating in Florida. Extensive research by Maxforce discovered that some German cockroaches avoided foods that contained the sugar glucose. Changing the sugar complex in the original gel bait matrix restored the attractiveness to these aberrant feeding cockroaches.

Currently, over 50 test gel formulae have been tested in the laboratory and the field. In many cases promising lab results could not be duplicated in the field. In other cases a specific test gel may have performed well in one geographic location, but not well in another. Extensive field trials with cooperators were performed against locations where aversion was documented as well as in locations against "normal" field strain populations.

In 2003 a test gel matrix was provided for field trials. Over 20 cooperative trials with PMPs were performed across the nation. Trial sites were selected based on confirmation of bait aversion and the presence of large populations of these German cockroaches. Visual counts of cockroaches were taken prior to application. During application feeding response was observed and control results were measured over time. In these trials cockroach feeding response to the test matrix was positive and control rates ranged from 80% to 100%.

As the result of these trials Bayer Environmental Science will release to the structural pest control market this gel formula as Maxforce FC Select Cockroach Bait Gel in 2004.

INDUSTRY PERSPECTIVES ON BAIT AVOIDANCE BY GERMAN COCKROACHES

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Orkin Pest Control Co.
Atlanta, GA

Since the mid 1980's baits have provided a major impact on the control of the domestic cockroaches such as the German cockroach, *Blattella germanica*, and the American cockroach, *Periplaneta americana*. Since the introduction of bait materials in the forms of gels, dust and containerized stations, the common roach has fallen from its place as the number one pest in America. The cockroach however is a survivor. In recent years the common cockroach has apparently learned to determine the potential lethality of bait placements in an account. Control measures have had to be re-taught to new technicians who have never had to use older materials and techniques.

This paper will examine the time line of the learned aversion and the control measure changes that have occurred. Also discussed will be the field work by the author and team on new and alternate materials.

AREA WIDE CONTROL OF THE FORMOSAN TERMITE

Regency Ballroom A

Moderator
Frank Guillot
USDA-ARS, SRRC
New Orleans, LA

RATIONAL FOR AREA-WIDE MANAGEMENT OF THE FORMOSAN SUBTERRANEAN TERMITE

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One characteristic of the Formosan subterranean termite, *C. formosanus* is its colony size. A single colony may contain several million termites and forage up to 100 m in soil. Because of the large colony size, application of soil termiticides beneath a structure usually does not impact the overall population, and the surviving colony continues to produce alates that further infest nearby areas. The dependency of soil termiticide barriers as the primary tool for subterranean termite control since the 1950s is probably one factor contributing to the spread of *C. formosanus* from 4 isolated port cities in the 1960s to the entire southeastern United States in 2000. With the availability of termite bait products, we now possess a technology to eliminate an individual colony of *C. formosanus*, but in regions densely populated with *C. formosanus*, vacated territories of colonies that had been eliminated by baits could be quickly re-occupied by neighboring populations. When a large area is clear of *C. formosanus* colonies, the edge distance/area ratio (akin to surface/volume ratio) decrease with the increases of the area, and thus reduces the probability of re-invasion by established near-by colonies. An area-wide management program is needed to suppress the overall populations of *C. formosanus* so that chances for the re-invasion and re-occupation by neighboring colonies are minimized.

ADVANCES IN TERMITE DETECTION TECHNOLOGY

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A critical factor in modern termite control is the ability to determine their presence in structures and trees. Current termite detection is firmly based in detailed inspection conducted by someone practiced in the art. Such inspection can be assisted with a flashlight and a sturdy probe, such as a screwdriver, for example, but is limited by accessibility to the inspector. Uses of in-ground cellulose monitors to congregate feeding termites and alate traps have also proven themselves as effective strategies for termite detection in an area, but not specific sites within a structure. Over the last decade, technological advances have made available a number of devices to assist in termite detection. Some of these devices include the resistograph (decay detecting drill), acoustical emission devices, moisture meters, thermal imaging, microwave imaging, methane detectors, portable X-ray devices, and laparoscopes. Additionally there are other technologies, ground penetrating radar for example, which are in the process of being adapted for termite detection applications. Many of these technologies are very effective in detecting termites on a small scale, but many become labor intensive and time consuming when their use is expanded for large-scale, day-to-day applications. Devices which will allow rapid, unequivocal detection of termites within structures are critically needed.

CONTROL OF FORMOSAN SUBTERRANEAN TERMITE (ISOPTERA: RHINOTERMITIDAE) INFESTATIONS IN ESPLANADE AVENUE, NEW ORLEANS, LOUISIANA USING BAITS

Juan A. Morales-Ramos and M. Guadalupe Rojas
USDA-ARS Southern Regional Research Center,
Formosan Subterranean Termite Research Unit

A field study was designed to test the feasibility of controlling infestations of the Formosan subterranean termite, *Coptotermes formosanus* Shiraki, in large trees. Esplanade avenue in New Orleans' French Quarter was selected as a study site because it possesses large middle ground areas with old trees of different species and also a large population of Formosan subterranean termites. Underground bait stations (Quarterra type) were installed in 2 lines along each side of the middle ground spaced approximately 5 m from each other. The Old Mint Museum located in Esplanade Avenue between French Market street and Decatur was used as a control for the Esplanade study. A total of 82

underground stations were installed around the museum building and next to large trees.

Stations were monitored monthly for termite activity. A bag with 150g of a bait formulation as described by Rojas and Morales-Ramos (2001) was deposited in stations with termite activity. From March 2002 to May 2003 the active ingredient was 250 ppm of diflubenzuron and 100 ppm of a synergistic blue colorant. From May 2003 the active ingredient was changed to 250 ppm of chlorfluazuron. Stations located within the Old Mint Museum were monitored for termite activity, but, were not baited.

A total of 51 stations (from 220) were visited by termites in Esplanade Avenue and 21 (from 82) in the Old Mint Museum. Formosan subterranean termites visited the majority of the stations with only 1 in Esplanade and 2 in the Old Mint being visited by eastern subterranean termites *Reticulitermes flavipes* (Kollar). Termites consumed 4.5 kg of the diflubenzuron-blue bait and termite activity continuously increased to 44 active stations out of a total of 220 stations within a period of 14 months. Bait consumption was low and termite activity was not reduced by this treatment. Termites consumed 6 kg of the chlorfluazuron formulation in an 8-mo period and termite activity declined from 44 active stations in May 2003 to 1 active station in February 2004 (Fig. 1). The number of active stations in the control increased steadily to June 2004 (Fig. 1A). The percentage of active stations from total visited stations by termites provides a better comparison of treatment and control eliminating bias by the difference in the number of installed stations (Fig. 1B). Consumption of the diflubenzuron-blue formulation was considerably slower and did not reduced termite activity. The chlorfluazuron formulation was consumed more rapidly (5.8 Kg within 5 mo.) and termite activity crashed between August and September 2003.

At the time the bait formulation was changed, stations 156-164 have been continuously active for at least the previous 6 mo. Termite activity in those stations ceased within 3 months of the initiation of chlorfluazuron treatment. During the same period of time, more than 50% of the stations located in the Old Mint museum remained active (Fig. 1). This rapid decline can be explained by the synergistic effect of one of the two active ingredients present in the previous treatment. In another study where a bait formulation of 250 ppm of diflubenzuron without blue colorant was replaced by 250 ppm of chlorfluazuron, termite activity ceased in the stations within 8 mo. of switching (J. A. Morales-Ramos unpublished). This is a possible indication that the colorant, and not the diflubenzuron, was responsible for the synergistic effect observed in Esplanade.

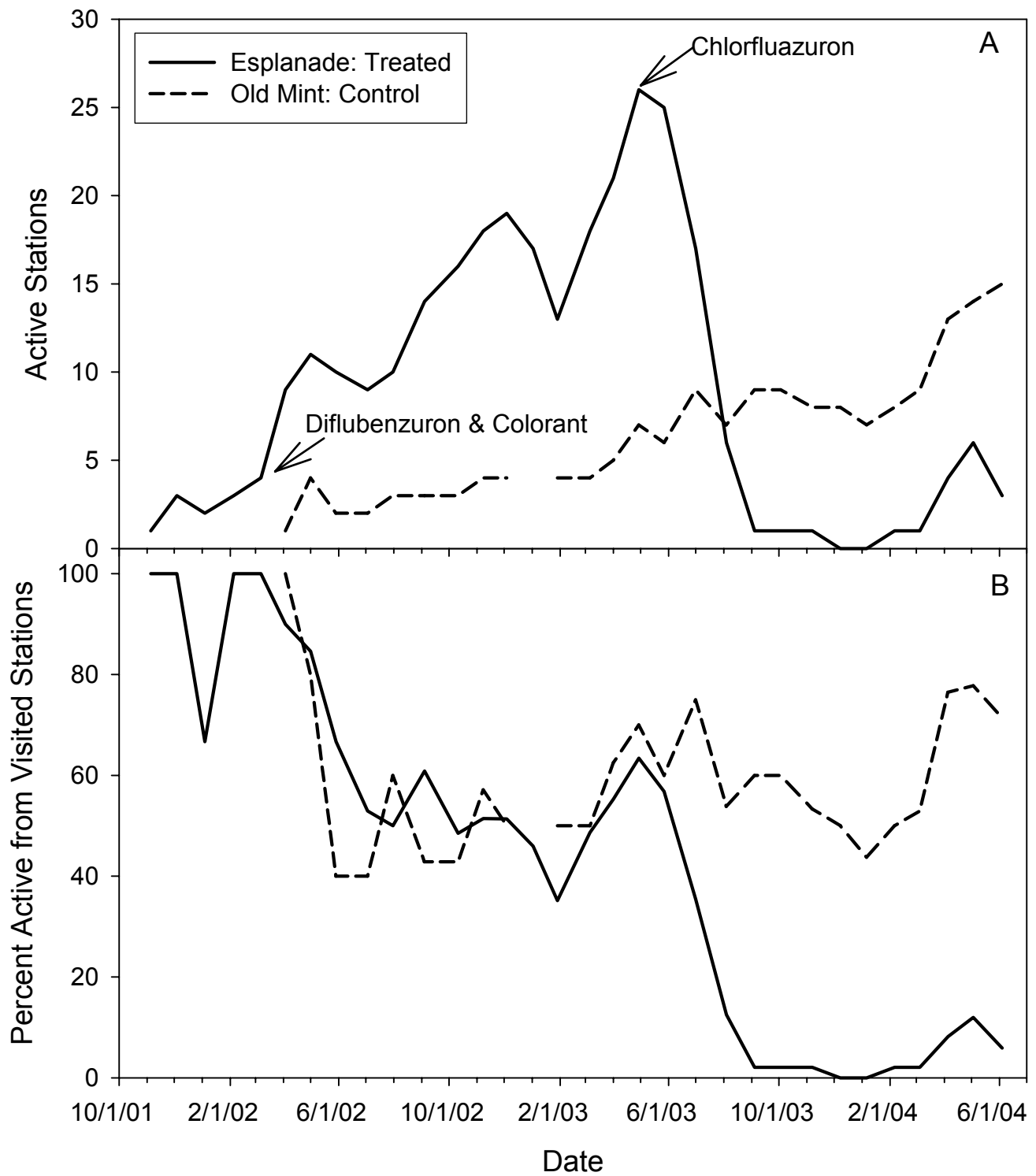


Figure 1. Termite Activity in Esplanade Avenue and The Old Mint Museum, New Orleans Louisiana between October 2001 and June 2004. A) Number of stations with termite activity. B) Percentage of active stations from the total number of stations visited by termites.

POPULATION DENSITY OF FORMOSAN SUBTERRANEAN TERMITES INFESTING THE RIVERFRONT RAILROAD IN NEW ORLEANS AND TREATMENT USING BAITS CONTAINING 0.5% NOVIFLUMURON

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The Formosan subterranean termite, *Coptotermes formosanus* Shiraki (Isoptera: Rhinotermitidae) has had a severe economic impact on the state of Louisiana. Since *C. formosanus* was first confirmed in New Orleans in 1966, infestations of this termite has continued to grow and have become a threat to the structural integrity of many structures, including those of historic significance. In addition to damaging structures, this termite has been frequently found in live trees, landscape timbers, planters, and railroad ties. The historic French Quarter has also had a long history of severe termite pressure by this species and it has become well established in the buildings, trees, gardens, and the railroad tracks that run along the Mississippi River. The tracks run between the Mississippi River levee and the flood walls are in an area that has never received any kind of termite treatment. Because of the termite pressure, high precipitation, and lack of termite treatment, these creosote treated ties have been replaced more frequently than in other areas with less termite pressure. A study was initiated in January 2002 to access and then reduce the termite pressure along one mile of railroad tracks that runs along the French Quarter. Four hundred eighty Sentricon[®] stations ([®]Registered trademark of Dow AgroSciences LLC, Indianapolis, IN) were installed along the mile of track and on the nearby levee around the 5 feet by 5 feet creosote or CCA-treated wooden planters. The coordinates of the stations were collected with a Trimble Pro XRS GPS System, using EVEREST Multipath Rejection Technology. The foraging territory of each colony was determined using a mark-release-recapture procedure prior to baiting. In addition, termites (100 termites/station) were collected from every active station and were placed in 95% EtOH for microsatellite genotyping. Together with mark-release-recapture, the genetic differentiation between collection sites helped determine the number and minimum extent of the colonies present along the railroad tracks and planters.

In September 2003, termite bait containing 0.5% noviflumuron was installed in Sentricon stations with termites. This research is still in progress. It has provided valuable information about the population density of termite colonies along the railroad tracks and is making a significant contribution to the ongoing

efforts of termite management in the French Quarter and in the State of Louisiana.

DISTRIBUTION AND DISPERSAL OF THE FORMOSAN SUBTERRANEAN TERMITE- MISSISSIPPI, A CASE STUDY

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The Formosan subterranean termite, *Coptotermes formosanus* was first identified in the mainland US in 1965 although it had been discovered and misidentified earlier. It was originally brought to this country in military cargo returning from the Pacific theater of WWII based upon the locations of its earliest discovery. From the initial discovery in New Orleans and Lake Charles, LA; Houston/Galveston, TX and Charleston, SC in the mid-1960s the termite is now known to have been identified in eleven states including Hawaii. The heaviest infestations are in the coastal regions of the Gulf south and the northernmost range is North Carolina. Continued surveys by pest management professionals, extension personnel and termite researchers reveal an expanding range of this important and devastating pest.

Recent resurgence of the termites in areas of North Carolina where the termite was believed to have been eliminated attest to the tenacity of the termite once introduced into an area. While the termite does not expand its range significantly through dispersal flights or expansion of its foraging territory, man's intervention through distribution of infested materials has resulted in the expansion of its range throughout the South. Railway ties which have been recycled as landscape timbers have been consistently reported to be involved in the distribution of this termite particularly in Georgia and Texas.

Ongoing surveys for the FST in south Mississippi continue to reveal new locations of infestation, particularly in rural areas. In many of these cases there are no obvious signs of importation of railway ties as landscape timbers; however, there has been close association of the location of these newly discovered infestations with railways and/or landfills. A quarantine enacted by Mississippi is designed to prevent further spread into uninfested areas and recent action has resulted in the quarantine of infested railway ties. Improved monitoring will help identify areas having the FST where control efforts should be initiated. Education of wood products industry and citizens groups will provide assistance in reducing the spread of this pest.

AREA-WIDE PEST MANAGEMENT OF FORMOSAN SUBTERRANEAN TERMITES IN THE FRENCH QUARTER, NEW ORLEANS, LOUISIANA

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The Formosan subterranean termite, *Coptotermes formosanus*, is a serious pest where it has become established and is one of the most destructive insects in Louisiana. The density of the Formosan subterranean termites in the French Quarter, New Orleans, Louisiana, USA is very high. A pilot test was begun in 1998 in the French Quarter to demonstrate the effectiveness of using area wide management to reduce densities of termites rather than treating individual structures. The pilot test is a cooperative effort between the LSU Agricultural Center, USDA-Agricultural Research Service and New Orleans Mosquito and Termite Control Board. All properties in a contiguous 15 block area in the French Quarter were treated using commercially available baits or non repellent termiticides selected by property owners and applied by professional pest control operators. In 2002 the treatment zone was expanded to include the immediately surrounding blocks. Glue boards were used to estimate alate numbers and in-ground monitors for foraging activity. Alates were sampled once a week in April and two to three times weekly during the flight season (May through July 15) in 1998 through 2003. Monthly monitoring of foraging activity began in January, 1999 to determine the number of stations with termites. Inspection reports of commercial bait stations were also collected to determine the in-ground activity. These data showed that area-wide management reduced termite activity in the 15-block area. An overall 50% reduction in termite numbers and activity was observed. Isolated areas of "high" termite activity remain inside the test area. Inspections of properties using infrared and acoustic detection technologies are being conducted to allow discovery and treatment of colonies which have, so far, escaped treatment. Visual inspections of courtyards and trees are being conducted to detect and treat termites in the treated area outside of structures. A third expansion began in March of 2003. Continued treatment, expansion, and monitoring are required to assess the long-term effects of the area wide management program.

COCKROACHES

Regency Ballroom B

Moderator

**Deanna Branscome
University of Florida
Gainesville, FL**

PALATABILITY AND EFFICACY OF A NEW GEL BAIT FOR CONTROL OF GERMAN COCKROACHES IN A FIELD SETTING

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Recent studies revealed high levels of behavioral and physiological resistance to gel baits in some field German cockroach populations. There is a strong interest in developing new cockroach baits. Noviflumuron is a chitin synthesis inhibitor discovered by Dow AgroSciences. It began to be used for termite control in 2003. Studies by researchers from Dow AgroSciences and Purdue University showed that noviflumuron had high insecticidal activity against German cockroaches. In this study, we aimed to: 1) compare the palatability of a noviflumuron based gel bait with Maxforce[®] FC gel bait (0.01% fipronil) and Avert[®] gel bait (0.05% abamectin); and 2) compare the efficacy of noviflumuron gel bait, Maxforce[®] FC gel bait, and Demand[®] liquid spray against field German cockroach populations.

Studies were conducted in multifamily housing units located in Gary, IN. Apartments with heavy German cockroach infestations were selected. In the palatability study, a total of 71 replications located in 10 apartments were applied. Bait consumption was measured 4 weeks after placement. Noviflumuron gel bait was significantly more palatable than Maxforce[®] FC and Avert[®] based on consumption levels.

In the efficacy study, at least 15 apartments were included in each treatment. Results were monitored at 2, 4, 8, 12, and 16 wks. Both of the two bait treatments caused apparent cockroach population reduction from 2 wk after treatment, whereas those apartments that received Demand[®] treatment experienced increased cockroach populations at 2, 4, and 8 wk after treatment.

At 8 wk after initial treatment, Maxforce® and noviflumuron caused 43.0 ± 33.9 and $88.7 \pm 3.5\%$ population reduction, respectively. Percentages of apartments with >70% population reduction in Maxforce® and noviflumuron treatments were 68.8 and 87.5%, respectively. Noviflumuron gel bait resulted in higher control than Maxforce® at 8, 12, and 16 wk. However, the differences between the baits were not statistically significant. Noviflumuron gel bait reached the highest performance at week 8 based on the number of apartments with satisfactory control and the mean population reduction. Results from this study indicate that noviflumuron gel bait is highly palatable and can provide similar control of field German cockroach populations as Maxforce® FC gel bait.

CHARACTERISTICS OF A GEL BAIT AVERSE STRAIN OF GERMAN COCKROACH

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A highly resistant strain of German cockroach ("Cincy") was collected in a multifamily housing complex in Cincinnati, OH. The account received repeated gel bait treatments for more than 5 years. Females of this strain produced significantly smaller oothecae than the laboratory strain ("Jwax") and a field strain ("Dorie") that without apparent resistance. Topical and feeding studies showed that the strain developed both physiological and behavioral resistance. Maxforce® FC (0.01% fipronil), Maxforce® (2.15% hydramethylnon), Pre-Empt™ (2.15% imidacloprid), and Avert® (0.05% abamectin) gel baits only caused 0-40% mortality of this bait averse strain in laboratory choice feeding assays. Reduced feeding was apparently the main cause of the resistance. The aversion was caused by the inert ingredients in the baits. The "Cincy" strain exhibited negative response to food containing fructose, maltose, sucrose, and glucose, which are common food ingredients and phagostimulants to non-averse "Jwax" strain. Changing bait formulas in Maxforce® baits significantly improved the efficacy. Reciprocal cross of "Cincy" and "Jwax" strains indicates that the bait aversion is inherited as an autosomal incompletely dominant trait. Cockroach control history played an important role in the development of bait aversion behavior. This study demonstrates that German cockroaches have the ability to develop behavioral resistance to toxic baits as well as physiological resistance to the active ingredients.

AMERICAN COCKROACH SUPER NEST IN BURIED STUMP DUMP IN UPSTATE NEW YORK

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Consulting Entomologist
Extermitrain

In 1993, a land clearing debris landfill was established on rural property in the mid-Hudson Valley region of New York. In 1995, American Cockroaches were prevalent as far as two miles from the landfill and health department officials determined that the landfill site was the source of the infestations. In 1999, the Landfill was power sprayed with an insecticide, graded and capped, then monitored for American Cockroaches using glue boards in rodent bait stations placed throughout the site surface. This monitoring continued until the summer of 2002 with almost no cockroach captures.

Responding to continued neighborhood complaints, monitoring was revised in 2002 using containers baited with bread and beer placed in sinkhole openings and around the site perimeter which resulted in the capture of thousands of American cockroaches.

Because of the magnitude of the infestation and location of the site, it was determined that baiting was preferred and a boric acid granular bait (available commercially as NiBan) was used following a confirmation of acceptance.

The granular bait was injected into each of many existing sinkholes and broadcast over the entire site and around the site perimeter. Acceptance was immediate and subsequent monitoring resulted in significant capture reductions. New sinkholes continue to form, and monitoring reveals significant capture numbers prior to treatment.

The progress in this monitoring and treatment program indicates there is probably a tremendous core population of cockroaches deep within this landfill that have the ability to travel throughout caverns and tunnels within the system, and emerge as new sinkholes occur, each sinkhole providing an exit route. Interviews with the surrounding neighbors revealed absence of cockroach activity on or in their properties following the baiting program indicating that the granular bait was very successful in intercepting and eliminating those cockroaches moving toward the surface.

Lessons may be learned from the complications of this intricate site and how the severe infestation was ultimately brought under control. It may be possible to apply such knowledge to other similarly large and intricate environments in the future.

LABORATORY EVALUATIONS OF NOVIFLUMURON BAIT FORMULATIONS ON TWO SPECIES OF COCKROACHES

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Noviflumuron is a novel insect growth regulator (IGR) insecticide being developed by Dow AgroSciences LLC for use in a wide range of pest management solutions. Noviflumuron is a fast acting chitin synthesis inhibitor that is the active ingredient in Recruit™ III and Recruit™ AG termite baits used with the Sentricon® *Termite Colony Elimination System*, with excellent activity on subterranean termites as well as other key insect pests in the urban environment.

This paper will review laboratory evaluations of noviflumuron in bait formulations against the German cockroach, *Blattella germanica* (L.) and American cockroach, *Periplaneta americana* (L.). Noviflumuron bait matrices were highly efficacious on nymphal German and American cockroaches over a broad range of concentrations. In addition to direct nymphal kill (either through bait ingestion or secondary transfer), laboratory studies also show that noviflumuron can potentially impact German cockroach populations through impairment of reproduction. Bait matrix formulations of noviflumuron were highly palatable to both German and American cockroaches and significantly preferred over current commercial bait formulations in choice feeding tests. Overall results of these laboratory evaluations indicate that noviflumuron has excellent potential in bait formulations for control of cockroach populations.

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CONTROLLING AMERICAN COCKROACHES IN SEWERS

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American cockroaches, *Periplaneta americana* (L.), are a major pest in sewers in the southwest United States, requiring treatment by public work departments. Many municipalities routinely treat sewers to alleviate complaints by homeowners and local businesses. Sprays containing chlorfenapyr, deltamethrin, and imiprothrin + d-phenothrin; baits containing boric acid, hydramethylnon, and fipronil; and dusts containing boric acid and synergized pyrethins are registered for use in sewers. However, there is virtually no data available regarding their performance.

The primary objective of this study was to examine possible alternatives to conventional spray and insecticidal paint treatments of sewers. With the recent suspension of chlorpyrifos for such use and the reduction in the use of diazinon in urban settings, materials or formulations with low mammalian toxicity and the likelihood of causing minimal environmental impact, especially in sewage treatment facilities or filter ponds, were investigated.

An experimental dust consisting of 2.0% pyrethrins, 10% piperonyl butoxide, 35.5% boric acid, 50.0% diatomaceous earth, and 2% other ingredients (Environmental Products and Technologies Corp., Westlake Village, CA) was tested. It was applied to the sewer holes using a 30-gallon DeVilbiss air compressor at either 50 or 100 g per manhole. Single treatment of either 50 or 100 g rates provided > 98% reductions in cockroach counts for at least 3 months.

Imidacloprid gel bait (Pre-Empt) applied at 30 g per manhole on suspend cards provided > 89% reductions of cockroaches for 21 weeks. To prevent cockroaches from migrating from untreated lateral sewer shafts and the next manholes along the lateral line, the infested sewer shaft (target) and the next manhole along the sewer lines were treated. A narrow band of bait (30 g) was circumscribed around the top of the manhole just beneath the metal rim. Greater than 96% reductions were achieved in both target holes and next manholes on the lateral line adjacent for at least 6 months. Fipronil gel bait (0.05%) provided > 99% reductions for at least 6 months. Bait retrieved from manholes after 2 months was toxic to cockroaches, providing >85% kill in the laboratory tests.

A strategy that incorporates gel baits applied around the infested manhole (target hole) and the next manhole on the lateral line provides outstanding control. An additional 30 g of bait is re-applied whenever live cockroaches are seen in the manholes. Typically, only one re-application has been necessary to eliminate American cockroaches from the sewer holes. The strategy will be cost effective for municipalities having to treat large numbers of sewer shafts each year.

TRANSLOCATION OF *SALMONELLA ENTERICA* ON THE CUTICLE OF EXPERIMENTALLY INOCULATED *PERIPLANETA AMERICANA*

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Pronota (N=9) of live adult male American cockroaches were experimentally inoculated with 2 µl of a *Salmonella enterica* suspension containing 6.0×10^5 cells/µl and incubated for 24, 48 and 72 h. No *S. enterica* cells were recovered when pronota were processed in deionized water to quantify the amount of viable cells remaining at 24 to 72 h post inoculation. However, viable cells were recovered from the stock *S. enterica* solution at all time periods. Because microbiological recovery of *S. enterica* was not successful, examination of inoculated pronota was performed with scanning electron microscopy (SEM). Pronota (n=9) and tarsi (n=9) inoculated with *S. enterica* were removed from living cockroaches at 24 h and processed for SEM via fixation with osmium tetroxide vapors. Examination of specimens revealed no to few (N=5) bacterial cells on the surface of either pronota or tarsi. However, on one pronotal specimen, bacteria shaped indentations were observed underneath the wax layer. Because *S. enterica* cells were not present on the surface of the wax layer, another set of pronota (n=9) and tarsal (n=9) specimens were processed with another technique, glutaraldehyde fixation. Glutaraldehyde fixation removed a significant amount of the wax layer from the surface of the cuticle and revealed the presence of *S. enterica* cells, too numerous to count, affixed to the surface of the outer epicuticle and within residual wax. These data reveal that the flagellated *S. enterica* cells were able to penetrate the wax layer and adhere to the outer epicuticle as well as become enmeshed within the wax. Therefore it was concluded that 1) the wax layer cannot be covered by an impenetrable cement layer 2) that bacterial cells may remain protected from external environmental factors and 3) because the wax layer of American cockroaches is continuously sloughed off, the potential for mechanical transmission of *S. enterica* may occur for a period of several days to months.

TEACHING URBAN ENTOMOLOGY – WHAT WORKS AND WHAT DOESN'T

Regency Ballroom A

Moderator

Roger Gold

Texas A&M University

College Station, TX

TEACHING URBAN ENTOMOLOGY: WHAT WORKS AND WHAT DOESN'T

Dr. Roger E. Gold, Texas A&M University

The interest in teaching formal courses in Urban Entomology has been increasing in universities and colleges throughout the United States. This is due in part to the recognition by academic administrators that the major portion of Americans live in urban settings, and that these are people who are the clientele for the new century. The other factor that is driving the interest in Urban Entomology is that there are positions available for entomology and biology majors to work in the integrated management of insects associated with structures and with humans and their companion animals. One of the highest placement rates for entomology majors at Texas A&M University has been for both undergraduate and graduate students with training in urban entomology. They have been hired by other institutions to teach courses in urban entomology and general biology, by the military, by local, state and federal agencies that emphasize the implementation of insect control programs in schools, hospitals, nursing homes and other urban or industrial settings, and by commercial pest control companies. This symposium has been organized to address ways to best educate students in the skill set needed to be an effective urban entomologist. There are four presentations. The first will emphasize the development of specific lectures in a formal course in Urban Entomology. The second will discuss approaches to laboratory assignments and presentations. The third will be the use of urban insects in other entomology courses, and the last will be a discussion of what commercial companies expect of students coming out of urban entomology programs, and how companies work with students to prepare them for licensing and certification to work in the pest control industries.

THE PAYBACKS AND TRADE-OFFS OF TEACHING URBAN ENTOMOLOGY

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For a kid growing up in suburban New Jersey with a love of watching pavement ants it is no wonder that I should fall into an Urban Entomology position so comfortably. Likewise, teaching my discipline was a natural desire that helps promote the importance of my field of expertise. Students of entomology, however, are still largely agro-ecosystem oriented, and tend not to appreciate the importance the household-based relationship with insects provides to their potential future employment. Industry is strong in the support of such training because urban pests can bring in the highest returns on their investment. Teaching urban entomology requires a knowledge of all arthropods (and some vertebrates) that come into contact with homeowners, businesses and travelers. Biological attributes of each insect group are important to convey. Current control methods and chemistries for urban dwellers needing to manage insect pests make this discipline stand apart from most other entomological pursuits. Its similarity and overlap with Medical Entomology is both a blessing and a curse to the discipline that will be further discussed.

From my viewpoint, the most important aspect of teaching is to interact with students in a way that makes them active players in the learning process. Asking questions without always having the answer is one way to make classroom instruction dynamic. This requires instructional skills that enable one to organize a spontaneous discussion that is directed by the scientific method. Being an active researcher in Urban Entomology helps greatly in being disciplined in such a way and ensures that the most current information in the field is taught. The manner of presentation style needs to be varied to keep the student's interest, but my favorite interactive tool is the chalkboard. In my opinion, this information transport medium offers the flexibility needed to organize information resulting from student-teacher interactions. Watching my own teachers and observing the attributes that made them great, or, less-than-interesting, was always a hobby of mine. Being genuine and knocking down the barriers that are built-up because of a natural fear of public speaking is critical to being a successful teacher. A student taking a course in Urban Entomology will appreciate all insects as living creatures and know how best to manage them.

LABORATORY INSTRUCTION IN URBAN ENTOMOLOGY

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The objective of instruction using regularly scheduled laboratory sessions is to provide opportunities for students to learn through hands-on experience in conducting experiments, instruction in arthropod identification, and reinforcement of lecture themes. Laboratory sessions allow students to acquire valuable technical skills and expand their understanding of scientific concepts in a 'real world' context. Nurturing the students' spirit of inquiry and generation of an appreciation for the nature of scientific discovery are goals best accomplished through laboratory instruction.

The laboratory experience in an Urban Entomology class should involve instruction in the scientific method by hands-on experience with following protocols, recording data, and interpreting results from experiments involving aspects of the biology and control of various household and structural insects. In addition, laboratory sessions should include participating in field trips to collect insect specimens, observe insect management techniques, developing proficiency in the use of dichotomous morphological keys and sight identification of principle urban pests. These learning opportunities cannot be simulated in the lecture classroom – even with movies or other visual presentations. The laboratory classroom atmosphere provides knowledge through physical involvement as well as preparation of reports requiring synthesis of concepts making them an integral and irreplaceable part of the learning experience.

SERVICE LEARNING IN ENTOMOLOGY

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A service-learning project was introduced to students in a "General Entomology" class (Entomology 2001: Insects in the Environment) at Louisiana State University in Fall 2002 and 2003. Traditionally, the focus of this course was an individual insect collection, eventually discarded by the instructor. The old course project objectives taught students collection, curation, and identification of Louisiana's diverse insects. In 2002 and 2003, individuals in the class chose a "Community Partner" who would be the recipient of their personal insect collection, and the collection would serve to educate the public about insects they see. Incorporation of service learning into the Insects in the Environment class changed the paradigm of the course and gave more meaning, purpose, and

permanency to the students' insect collection. In Louisiana, >70,000 people will potentially see the collections that are displayed by county agents, and in 4-H and Girl Scout clubs, high school and elementary school classrooms, golf courses' clubhouses, and two nature centers in Louisiana. Not only were the old course objectives accomplished, but now new skills were incorporated such as communication, camaraderie, leadership, and civic responsibility, all of which are becoming increasingly important in many careers in entomology.

TEACHING URBAN ENTOMOLOGY EXPECTATIONS: A FIELD PERSPECTIVE

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Urban entomology is a multi-disciplinary science. Entomologists working in the urban field must possess a strong background in both basic and applied entomology. A thorough understanding of the recognition, biology and habits of arthropods common to urban environments must include knowledge of immature stages and arachnids. At least an introduction to the biology and habits of common vertebrate species that can serve as reservoirs of disease and arthropod parasites/vectors should also be a part of the curriculum in an undergraduate urban entomology program. Urban entomologists working in extension or for private firms are expected to have (and be able to effectively communicate) knowledge of government regulations and pest management tools including pesticides prior to their employment. Internships, mentoring programs, field trips, conferences and guest lectures from urban entomologists working in private industry can enhance undergraduate studies and help focus applied research in graduate programs.

NEW URBAN PESTS AND OLD PEST RESURGENCE

Regency Ballroom B

Moderator

Brian Cabrera

University of Florida, Ft. Lauderdale Research and Education Center
Davie, FL

THE "TREE TERMITE", *NASUTITERMES COSTALIS* (HOLMGREN)(TERMITIDAE: NASUTITERMITINAE): AN UNWELCOMED RESIDENT OF FLORIDA

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University of Florida, Ft. Lauderdale Research & Education Center

An established population of a non-endemic termite, *Nasutitermes costalis* (Holmgren) was discovered in May 2001 in Dania Beach, FL. The infestation was first noticed after foraging tubes were found on the outer walls of a family residence. A carton nest was later discovered in the attic space. Subsequent inspections in the surrounding neighborhood revealed the presence of numerous nests, infested trees and wood, and foraging tubes on structures, trees, and stationary objects. A survey of the area revealed the infestation was confined to a ca. 0.2 km² area comprised of residential, commercial, industrial, and undeveloped properties, and inland waterways. Dispersal flights occurred in late May coinciding with the onset of the summer rainy season. Based on the number of nests and evidence of at least one swarming season, it is estimated that the infestation started eight to ten years prior to its discovery. The greatest termite activity was observed in a vehicle storage lot, an undeveloped 8-acre site, and a commercial marina property. A high density of vehicles, debris, and weedy vegetation in the storage lot and thick vegetation in the fenced-off, 8-acre property allowed incipient *N. costalis* colonies to become established and flourish for several years without notice. Although the original site and source of introduction is unknown, we suspect the source was an infested boat or shipping container. Analysis of partial DNA sequences of specimens from the Dania Beach population, compared with those of specimens collected throughout the Greater and Lesser Antilles in the Caribbean Sea, indicate these termites originated from the island of Antigua.

Nasutitermes costalis is in the Termitidae – the ‘higher’ termite family characterized by a sterile worker caste and the absence of flagellate protozoa in the gut – and the sub-family Nasutitermitinae in which the soldiers have a conical nasus. A noxious defensive chemical is emitted from the fontanelle at the tip of the nasus. There are some 250 species of *Nasutitermes* worldwide. Twelve species, including *N. costalis*, have been identified as structural pests. There are about 74 neotropical *Nasutitermes* species; *N. costalis* is found throughout the West Indies and in Guyana and Venezuela. This species builds epigeal and arboreal nests, which is clearly evidenced in Dania Beach by the numerous, tumor-like carton nests found at the bases or crotches of trees and shrubs (it has been dubbed the “tree termite” due to this habit). The nests can be quite large, some measuring 50 cm or more in diameter. Colonies are polydomous and polygynous; in one case, thirteen queens were found inside a single nest. One interesting behavior of this species is the soldiers initiate foraging and will crawl out in the open. Trails are heavily marked with fecal spotting and eventually covered with foraging tubes by the workers who are recruited later by the soldiers. The open foraging behavior and the dark brown coloration of the *N. costalis* soldiers sometimes cause them to be mistaken for ants (in Jamaica, nasute termites are called “duck ants”).

Besides escaping detection while in secluded areas, a lack of pressure from natural enemies, effective defenses, and the ability to withstand occasional periods of cold temperatures may have also contributed to successful establishment of *N. costalis* in Dania Beach. Colonies thrived in areas populated with several ant species including big-headed ants, *Pheidole megacephala* (Fabr.) and *Pheidole* spp., the crazy ant, *Paratrechina longicornis* (Latreille), and the Florida carpenter ant, *Camponotus floridanus* (Buckley). In one instance, a large *N. costalis* carton nest at the base of a tree was removed and a large *C. floridanus* colony was found directly beneath it. And although the carton nests can be easily broken into, potential mammalian predators such as raccoons did not disturb them. The large numbers of soldiers in the colony, plus their sticky terpenoid defense secretion, seem to be an effective deterrent to predation. Finally, the carton nests may also protect colonies from low temperatures. Temperatures recorded in January 2002 from the inside of a nest exposed to direct sunlight during the day remained consistently above 30°C at night despite ambient temperatures as low as 7°C. A combination of the insulation provided by the intricate complex of cells in the carton nest and the extension of nests below ground apparently shielded colonies from cold temperatures.

Although this was the first established, land-based infestation of a *Nasutitermes* species, it is not the first time one has been found in southeastern Florida. In 1996, a sailboat in Ft. Lauderdale was found infested with *N. nigriceps* and in 2002 a yacht, also docked in Ft. Lauderdale, was infested with *N. acajutlae*. Both infested boats were subsequently fumigated. These three cases show introduction of *Nasutitermes* into southeastern Florida is definitely possible and why we believe future introductions of *Nasutitermes* spp. are likely. For the Dania

Beach infestation, a coordinated eradication program is underway but it will be several years before we know if it is successful.

AREA-WIDE ERADICATION PROGRAM FOR THE ARBOREAL TERMITE, *NASUTITERMES COSTALIS*, IN SOUTHEASTERN FLORIDA

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In May 2001, a flourishing infestation of the exotic arboreal termite, *Nasutitermes costalis* (Holmgren), was discovered in Dania Beach, Florida. This was the first land-based population of a *Nasutitermes* sp. in the continental U.S. and the first record of any higher termite (Family Termitidae) residing on a non-endemic land mass. We estimate that over 100 mature colonies were in the area by 2003. Over the 2.5 years since *N. costalis* was discovered in southeastern Florida, ca. 18 structures, including mobile homes, single-family houses, buildings, and boats were infested. Damage to four mobile homes was severe. Many wood items (e.g. plywood and pressboard sheets, a ladder, fencing, decorative pieces, a patio bar, etc.) were also damaged or destroyed. We suspect that *N. costalis* activity may have also contributed to or caused the death of at least six native live oak (*Quercus virginiana*) trees in one heavily infested yard.

In September 2002, a "Tree Termite Task Force" was convened to plan, implement, and verify the eradication of *N. costalis* from Dania Beach. The task force consisted of personnel from State (Florida Department of Agriculture and Consumer Services and University of Florida), private (pesticide manufacturers and pest management professionals), and non-profit (pest control associations) entities totaling some 60 individuals. Private sector participation was voluntary and extramural funding was limited to insecticide screening and field surveys. Because *N. costalis* is such a visible target species due to its above ground nests and dark foraging tubes, it was decided that eradication could be attempted most efficiently by direct application of liquid insecticides augmented by fumigation of infested structures.

In January 2003, an area-wide visual survey was conducted for nests, foraging tubes, foraging sites, and debris harboring live *N. costalis*. Location waypoints for active sites were recorded using a Global Positioning System receiver. A photograph and termite voucher sample was taken at each site. New sites were

marked at minimum 7-meter intervals until the entire infestation zone was surveyed. One hundred eighty-nine active sites were recorded and mapped onto a geo-referenced aerial photograph of the survey zone. Two hundred acres were surveyed of which about 20% contained active infestations on commercial, residential, and undeveloped properties. Maximum east-west and north-south separation of active sites was 1,000 and 850 meters, respectively. Infested areas were divided into ten treatment sectors. Dania Beach and Broward County officials gave their consent and support for the eradication effort and citizens in the eradication zone were notified and informed of treatments. Owners of infested properties signed treatment authorization forms. Public support for this project was overwhelming.

On 23 April 2003, field treatments were conducted. Five sectors were assigned for treatment with Premise® 2 (1,000 ppm imidicloprid) and five with Termidor® SC (1,200 ppm fipronil) insecticides. The sectors assigned to Premise treatment contained 99 active sites, while those for Termidor contained 89 sites. A treatment team, each consisting of a licensed applicator and two termite spotters using aerial maps for site reference, was assigned to each sector. *Nasutitermes costalis* activity located by spotters was sprayed with either a truck-mounted or backpack applicator. Tracker® blue dye was added to all spray solutions to mark sprayed areas and to prevent over spray. Two boats in dry storage and two office trailers containing aerial colonies of *N. costalis* were fumigated with Vikane® gas fumigant at the non-monitored drywood termite rate. A total of 336 gallons of Premise 2, 447 gallons of Termidor SC, and 40 lbs of Vikane® was applied.

In June 2003, 69 active sites were located during a post-treatment survey of the entire area. No live termites were detected in the fumigated structures. Sixty active sites were recorded in Premise-treated sectors, while nine active sites were found in sectors treated with Termidor. All five sectors treated with Premise had at least three active sites while only one sector treated with Termidor contained live termites. Termidor was selected for use in all further eradication treatments. Because the majority of active sites (59) occurred on a heavily wooded 8-acre lot, it was decided to first implement a small-scale retreatment effort outside this lot. Using previous methods, 44 gallons of Termidor was applied to active sites outside of the wooded lot on 12 and 15 September 2003.

A November-December 2003 survey revealed that live *N. costalis* populations were now limited to 75 sites on or near the fence line of the wooded lot. The lot was divided into six treatment sectors and on 18 December 2003, six teams applied a total of 590 gallons of Termidor. A February 2004 survey found no live termites on the wooded lot or its fence line, and only one incipient colony was found and removed from another area previously known to be infested. One mature nest, found in April 2004 by a homeowner clearing heavy debris in his yard, was also removed.

Success of this program will be measured over time, however, given the conspicuous behavior of *N. costalis*, the eradication treatments have now greatly reduced, if not eliminated, all mature colonies in the known area of infestation. Because a number of dispersal flight seasons preceded the treatments, the potential exists for survivorship of incipient colonies that have yet to reveal themselves. Had this eradication program not been implemented, our expectation was that, decades later, large tracts of urban and rural south Florida would become infested with *N. costalis* resulting in great economic losses.

The *N. costalis* experience in southeastern Florida also brings to light a lack of a public policy for reacting to such inevitable urban pest invasions in the United States. With the exception of the New Orleans Mosquito and Termite Control Board, no local, state, or federal agency has a mandate to react to an outbreak of non-agricultural or non-medical pests. A policy to deal with exotic structural pests might prevent or, at least, decelerate widespread economic losses in any such future event.

ALTERNATIVE BEDBUG CONTROL

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Atlanta, GA

Approximately 1998 – 1999, the common Bed Bug, *Cimex lectularius*, began to make an apparent and impressive comeback in the United States. Control measures for this insect were in many cases long forgotten and badly outdated for today's litigious society. No current research was available to determine the proper and effective treatment techniques for this unusual insect. In 1999, the author started a field study and trail to determine the best treatment strategy while minimizing the amount of pesticides in the environment.

STINGING ANTS: CASE HISTORIES OF THREE NATIVE NORTH AMERICAN SPECIES

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There are sixty-two genera of ants in the Nearctic region (Bolton 1994).

Solenopsis and *Pogonomyrmex* are the most common causes of anaphylaxis by stinging (Pinnas 2001). An exotic species, *S. invicta* Buren, is the most common cause of insect venom allergy in the southeastern United States (Taber 2000).

Far fewer medical emergencies have been documented for our native species of *Solenopsis*, *Pogonomyrmex*, and *Pseudomyrmex*. Here we report on three recent cases:

Case 1. A 41-year old Caucasian male was brought to the University Medical Center, Tucson, Arizona by ambulance. He stated that he had painful ant "bites" to his groin and that he was now short of breath and dizzy. Upon admission to the Emergency Room the blood pressure was 89/64 mm Hg; pulse, 112 beats/minute; respirations, 22/minute and a temperature of 36.0⁰ C. He was disheveled, intoxicated and in significant respiratory distress. There was marked periorbital and perioral edema with cyanosis of the lips. There was severe wheezing present throughout both lung fields and marked erythema of the right groin area including the scrotum. Four hours later the patient had returned to his normal state of health. An extremely tender and enlarged lymph node was present in the right groin along with a large red papule, ~1x1x1 cm, with piloerection (gooseflesh) of the surrounding hairs in the vicinity of the papule. Ambulance records were retrieved and the exact site where the patient was picked up was visited. A *Pogonomyrmex rugosus* nest was present under the edge of the sidewalk where the patient had been sitting.

Case 2. About 30 minutes after last being checked, a three-month-old baby girl, indoors in her crib, was discovered covered with native fire ants, *Solenopsis xyloni*. She was in respiratory distress and taken by helicopter to a local hospital where she died. She received hundreds of stings. The ants were removed from the baby's body and positively identified. Specific IgE tests positive for fire ant *Solenopsis invicta* (total cross-reactivity among venoms within the genus *Solenopsis* is known) confirmed fire ants as the culprits. This supported initial medical observations that the death likely resulted from an allergic reaction (Type I hypersensitivity). Post mortem serum tryptase levels were elevated, confirming an anaphylactic reaction. This is the first confirmed case that has come to our

attention of a death from stings of this native fire ant species in which the cause of death as anaphylaxis can be clearly demonstrated.

Case 3. In September 2002, an Extension Agent in South Georgia sent an insect and note to the University of Georgia Experiment Station, which indicated that it had "bit" a man and caused a severe reaction. The patient was hospitalized with a generalized allergic reaction to envenomation by a species of *Pseudomyrmex*. The reaction was characterized by total body erythema, pruritus and agitation. He was treated with benedryl and steroids and improved.

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THE MULTICOLORED ASIAN LADY BEETLE: GOOD LADIES WITH SOME BAD HABITS

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The multicolored Asian lady beetle, *Harmonia axyridis*, was introduced into the United States by USDA-ARS as a biological control agent for aphids. While much heralded for its biocontrol activity, it has spread rapidly throughout North America displacing many of the native coccinellids. Drove of multicolored Asian lady beetles now migrate from trees and fields in late summer and autumn looking for other sources of food and favorable overwintering sites. This has created new problems for fruit growers as these lady beetles feed on grapes, apples, and peaches. Homeowners can be inundated with lady beetles seeking protected sites in and around buildings. Multicolored Asian lady beetles are frequently reported as nuisance pests that invade homes. Complaints also center on their foul odor, staining due to reflex bleeding, and biting behavior. Some individuals report dermal or respiratory allergic reactions. This presentation will discuss some of the costs and benefits associated with the multicolored Asian lady beetle.

MEET THE WHITE-FOOTED ANT

John Warner and Rudolf H. Scheffrahn
University of Florida

White-footed ants (WFA), *Technomyrmex albipes* (Hymenoptera: Formicidae), first collected by Alfred R. Wallace during historic voyages to Southeast Asia in the 1860's, were described from Sulawesi, Indonesia and have spread to many parts of the world, including the southern half of Florida, where they have become established as a household pest ant. A member of the Dolichoderinae subfamily, WFA intercastes are capable of producing large interconnected colonies of 8,000 to over 3 million individuals with about half of the population consisting of reproductives. Winged males and females are released from nests in large numbers between June and October in South Florida. Indoor flights of males, resembling gnats, are alarming to occupants. The WFA is a medium small (2.5 to 3 mm long), black to brownish-black ant with yellowish-white tibia and tarsi (feet), a petiole with no post-petiole (a "one-node" ant), and does not bite, sting nor cause structural damage. White-footed ants are arboreal, prefer to feed on honeydews and nectars but in urban settings will cause alarm to residents as they establish numerous trails into homes foraging for water and sweet liquids. Pest control operators find controlling this ant a challenge because nests are established in diffused networks in the structure and in landscape plants. Many locations are overlooked during treatments, allowing the population to rapidly rebound.

TERMITES, SATURDAY SESSION

May 22, 2004

Regency Ballroom B

Moderator
Susan Jones
Ohio State University
Columbus, OH

TERMITE TO TERMITE TRANSFER OF NON-REPELLENTS IN TERMITES: CHARACTERIZATION AND COMMERCIAL REALIZATION IN THE FIELD

Phil McNally, David Price, Karl Morris
Bayer Environmental Science

In 1995, Bayer Environmental Science introduced Premise^R termiticide (imidacloprid) to the pest control industry, whose unique mode of action revolutionized termite control technology. The non-repellent nature of Premise^R termiticide gave the PMP the ability to not only immediately protect the structure, but also to kill the termite population associated with the structure; something that pyrethroids could not do. This resulted in a general lowering of population levels of termites and a consequent lower likelihood of re-infestation of populations from outside the treated zone. This phenomenon has been observed in Hawaii where PMPs noted a reduction in the number of Formosan termite-infested structures, carton nests, and size of swarms between 2000 and the present compared to the early 1990s - before the introduction of this new technology.

Additional studies by Bayer Environmental Science and the University of Florida revealed that Premise^R termiticide at low sub-lethal soil concentrations conferred an enhanced susceptibility to pathogenic microorganisms. This resulted in even greater mortality of the general termite population. This attribute of Premise^R termiticide is still unique today - even among the other non-repellents commercially available and under development.

In 1995, the second author discovered a third attribute of Premise^R termiticide, a mode of acquisition that had never been previously reported in non-repellent termiticide studies - the lethal transfer of a non-repellent termiticide from termite to termite (secondary exposure or “Domino EffectTM”). This paper summarizes the seminal secondary exposure studies with imidacloprid, additional comparative studies with three other non-repellent termiticides, and studies which demonstrate the Domino EffectTM from commercial applications of Premise^R termiticide.

Figures one and two demonstrate the mortality from secondary exposure to imidacloprid at 100 ppm and 1 ppm in the laboratory. Figure three illustrates the relative efficacy and speed of kill in two colonies from secondary exposure to four non-repellents commercially available or under development. The more efficient and faster speed of kill from secondary exposure observed with imidacloprid and fipronil translates into more effective lethal transfer of imidacloprid and fipronil compared to thiamethoxam and chlorfenapyr during brief periods of termite to termite contact.

Figure 1. Mortality from secondary exposure to Premise^R termiticide. Initial one-hour exposure of 100 ppm of Premise for primary exposed (donor) termites

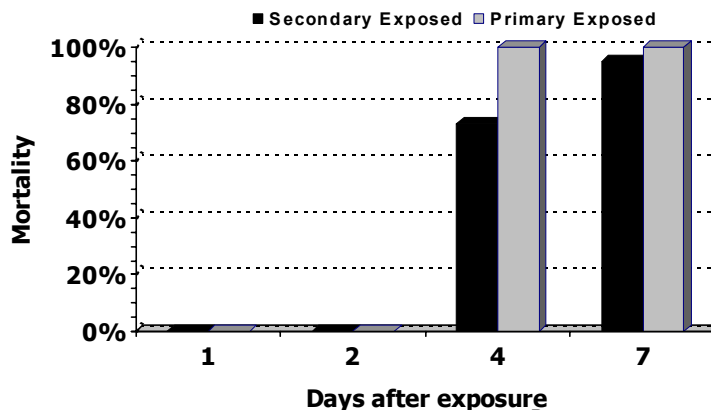


Figure 2. Mortality from secondary exposure to Premise^R termiticide. Initial one-hour exposure of 1 ppm of Premise for primary exposed termites (donors).

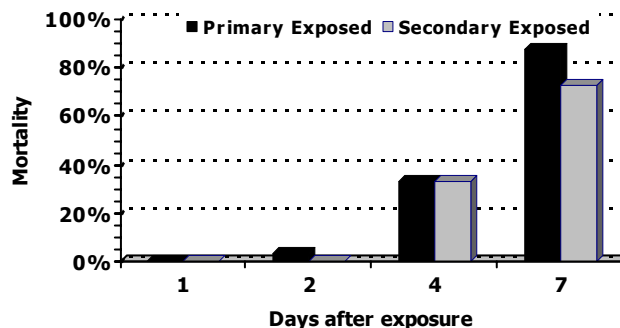
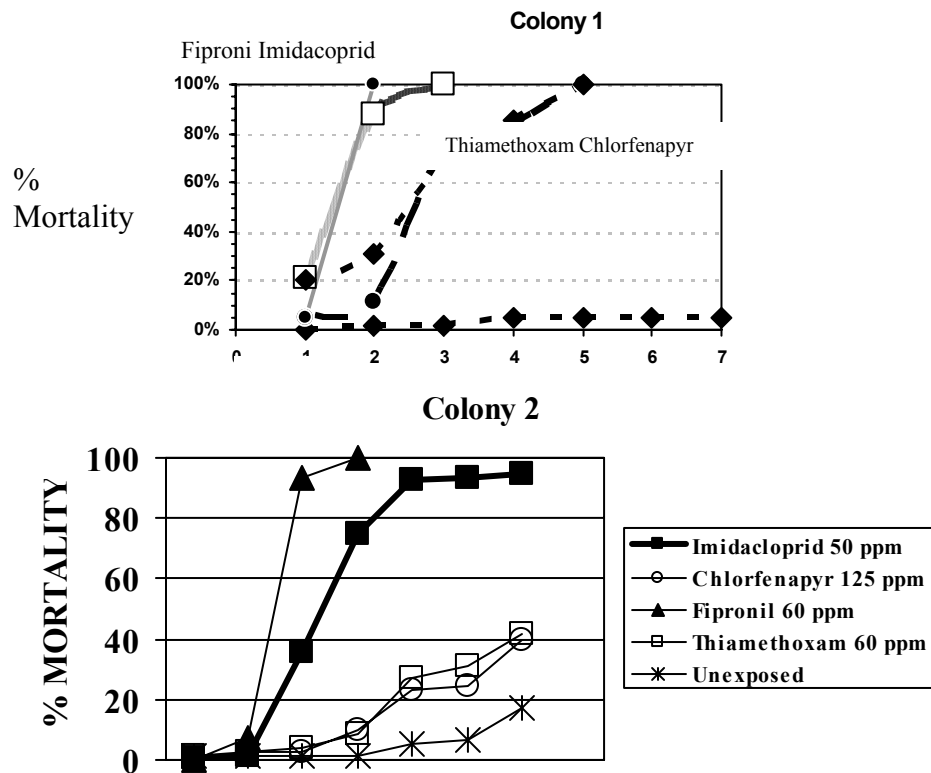


Figure 3. Mortality from secondary exposure to four non-repellent termiticides.



Field studies discussed in the presentation demonstrate the movement of termites in the field from the treated Premise zone to outside the treated zone where - before they die - they are able to transfer Premise to other termites which had never entered the treated zone.

PROTIST COMMUNITIES FROM FOUR CASTES AND THREE SPECIES OF SUBTERRANEAN TERMITES (ISOPTERA: RHINOTERMITIDAE)

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The literature states that subterranean termite protist communities are similar within, but differ between castes. We looked at protist communities from four castes of *Reticulitermes flavipes* (Kollar), *Reticulitermes virginicus* (Banks), and *Reticulitermes hageni* Banks. Termite workers and nymphs had the largest population of protists, followed by soldiers, and alates. *Reticulitermes flavipes* workers had $58,434 \pm 13,200$ flagellates compared to $20,779 \pm 3,582$ in *R.*

hageni and $14,017 \pm 3,482$ in *R. virginicus*. We found no difference in the protist communities between termite castes, but did find differences between termite species. Our study demonstrates the utility of using protist species proportions for identifying three eastern subterranean termites to species and calls for a re-evaluation of the role played by the various protist symbionts found in subterranean termites.

TRANSFER OF [14C]IMIDACLOPRID AMONG WORKERS OF THE SUBTERRANEAN TERMITE, *RETICULITERMES FLAVIPES*

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Abstract: Imidacloprid, the active ingredient in Premise[®], is a slow-acting, non-repellent termiticide used to control termites in residential and commercial applications. It is known that imidacloprid is transferred among termites throughout the colony resulting in the elimination of termites at considerable distances from the treated area. However, the mechanisms of transfer are not clear. Using digital video and [14C]imidacloprid studies, we show that imidacloprid transport by topically applied workers (donors) of *Reticulitermes flavipes*, and subsequent grooming and ingestion by untreated nestmates (recipients), is a major transport/transfer mechanism of this AI among termites in the lab. Soldiers do not acquire toxic amounts of imidacloprid from donors, since the soldiers were not observed to groom them. Workers acquired imidacloprid via cannibalism mainly by grooming and consuming the contaminated cuticle of the corpse. Imidacloprid appears stable on the cuticle surface under the conditions of the experiment, but is metabolized internally to at least two, more polar compounds.

RESPONSES OF *RETICULITERMES HESPERUS* FOR CARBOHYDRATES AS PHAGOSTIMULANTS AND AN ENERGY SOURCE

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Subterranean termites have a wide range of feeding preferences towards synthetic and natural substances (Mishra 1992, Chen and Henderson 1996, Morales-Ramos and Rojas 2001, Reinhard et al. 2002, Cornelius 2003). The subterranean termites *Reticulitermes santonensis* De Feytaud preferred filter paper treated with secretions from the labial glands, different sugar-like

components and amino acids (Reinhard and Kaib 2001). Waller and Curtis (2003) found an increased consumption of filter paper treated with solution of glucose, sucrose and xylose in *Reticulitermes flavipes* (Kollar) and *Reticulitermes virginicus* (Banks). Even though termites show an increased consumption when offered filter paper treated with simple carbohydrates, the fate and exchange of simple carbohydrates between the termites are not clear.

In our present study we determined the preferences of *R. hesperus* for different carbohydrates. Using ^{14}C -sucrose we examined the fate of a simple carbohydrate such as sucrose and exchange of this ^{14}C -sucrose among termites after ingestion. Western subterranean termites, *Reticulitermes hesperus* (Banks), show a feeding preference towards various mono-, di-, and trisaccharides. Total feeding was greatest on paper disks treated with 5% ribose followed by 3% xylose, 2% maltose, 2% fructose, 2% arabinose and 2% ribose (Figure 1). The carbohydrate concentrations were selected by initial screening of feeding amounts (mg) on 1%, 2%, 3% and 5% treated paper towel disks. Our study with ^{14}C -sucrose showed that termites can utilize this carbohydrate. Most of the sucrose was used as an energy source for respiration (89.25%), a very small proportion remains within the termite (9.24%) and even a smaller amount is excreted as solid waste (1.5%) (Figure 2). The amount of ^{14}C label transferred to other colony members via trophallaxis is directly dependent upon the time and numbers of donors and recipients. At day 15 post-mixing, the percentage transfer was highest, 14.42% and 15.10% for both 1:1 and 2:1 donor to recipient mixing ratios, respectively (Figure 3). The mean amount of labeled ^{14}C received by recipients increased from 7 disintegrations per minute (DPM) on day 2 to 30 DPM on day 15 for 1: 1.

This research suggests the potential use of simple carbohydrates in termite baits to make them more palatable which may lead to higher consumption of such baits and eventually a more efficient movement of slow acting IGRs both in terms of time and quantity.

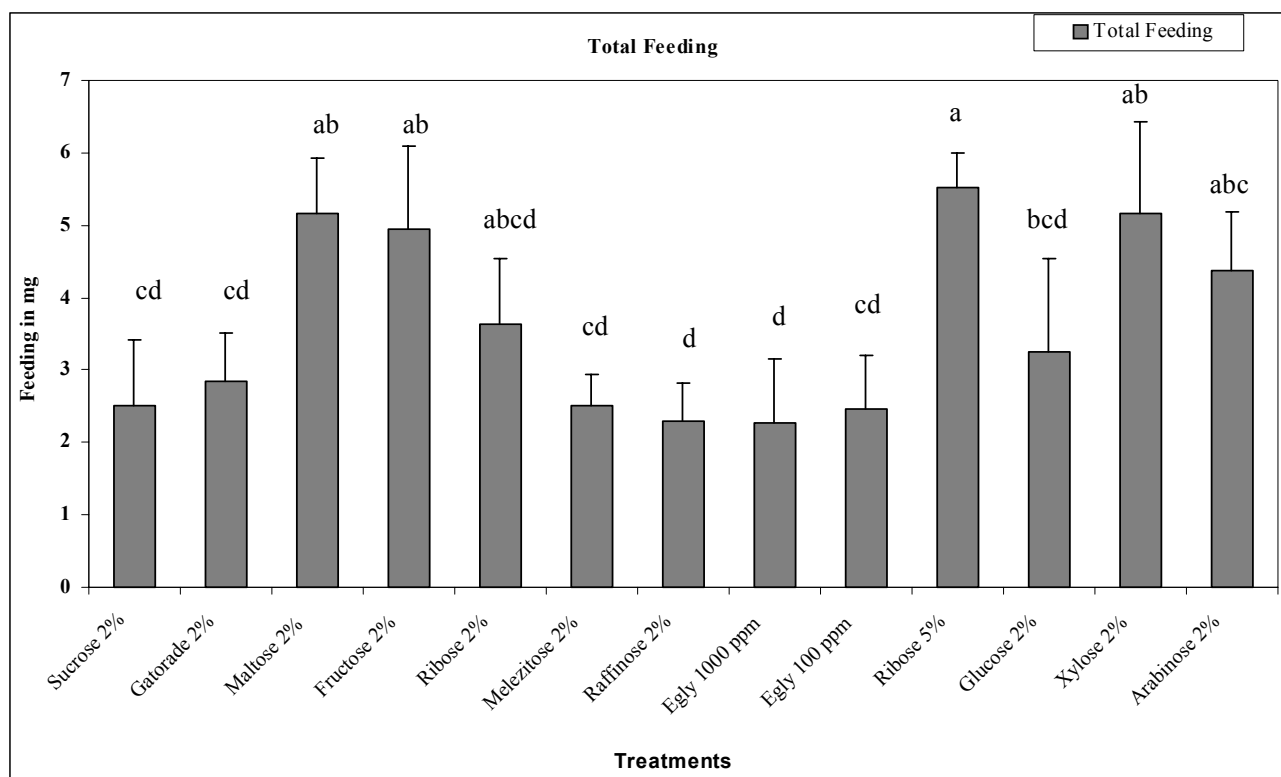


Figure 1. Total feeding (mg) of treated paper and control paper discs together by termites (n = 40) over 5 d in each setup. Columns with same letter are not significantly different at $P < 0.05$ (Tukey HSD).

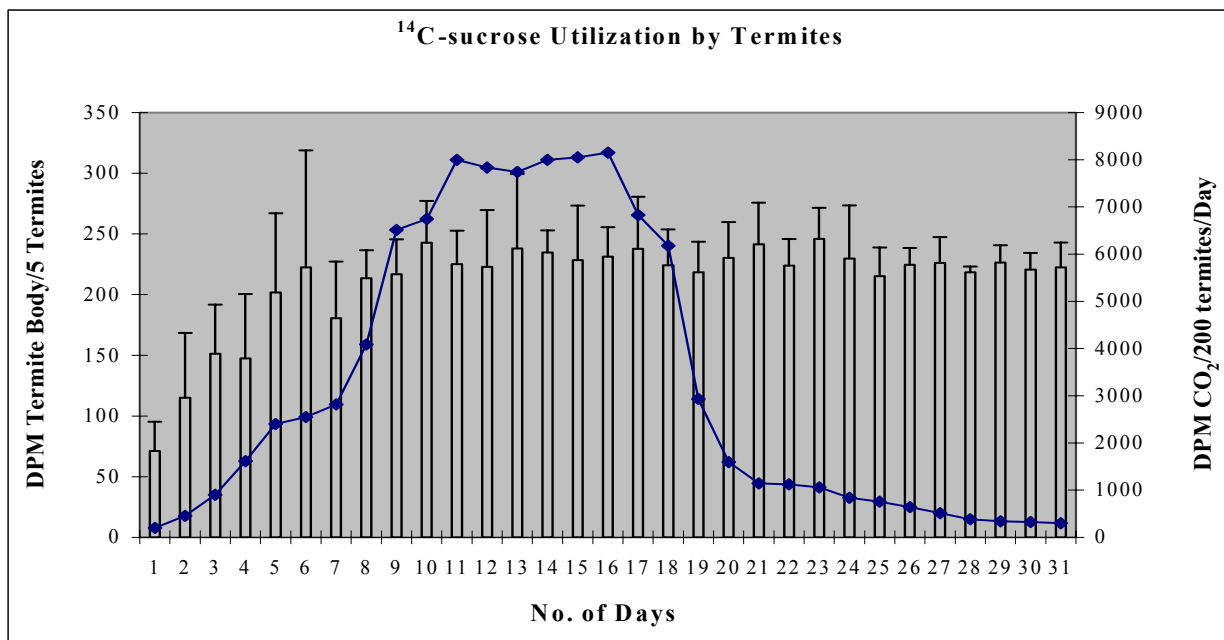


Figure 2. Uptake and respiration of ^{14}C -sucrose by termites. Termites fed on ^{14}C -sucrose treated filter paper for 16 d and then provided with untreated filter paper. Recovery of ^{14}C both from the termites (bars) and as CO_2 (line graph) produced by termites was recorded over 31 d. Bars indicate standard deviations.

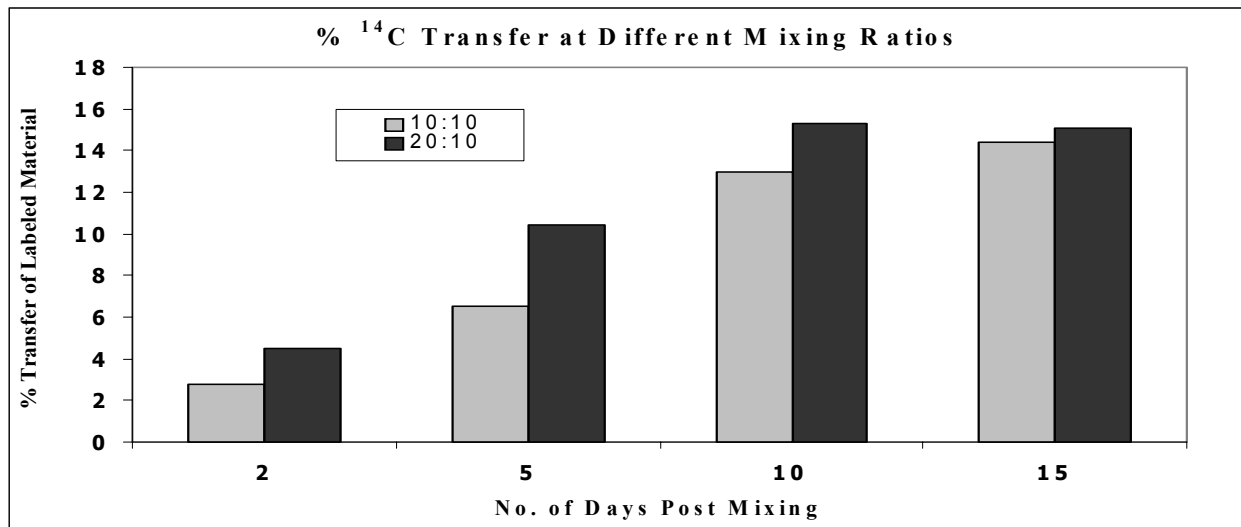


Figure 3. Donor and recipient levels of ¹⁴C-sucrose at 2, 5 10, and 15 d after mixing termite workers in two different ratios (1:1 and 2:1 donor to recipient). Donor termites were fed on radio labeled filter paper for 15 d before mixing.

*Percent Transfer calculated as (DPM recipients*100/DPM donors + recipients).

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IMIDACLOPRID AS AN EXTERIOR TREATMENT AND INTERIOR FOAM APPLICATION

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We tested the efficacy of Imidacloprid (Premise® 75 WSP) as an exterior treatment only in conjunction with Premise foam (LF) for interior application for control of *Heterotermes aureus* infestations. Ten infested single-family dwellings were selected in the Tucson metropolitan area to undergo exterior treatment only of Premise 75 WSP at rate of 0.05%. Where interior infestation sites were found, Premise foam was applied at the rate of 0.05%. Selected home sites had not received any termite treatment within the past 12 months prior to application of Premise. All homes were monitored for the presence of termites at various times starting 7 days post treatment and at least monthly thereafter. All 10 homes were termite free within 7 days post treatment. All areas of interior infestation where Premise foam was applied were clear of termites within 7 days. Nine homes within the study have remained termite free for 6 months. One home required a minimal re-treatment along an expansion joint abutting its garage and the stem wall of the garage abutting a sidewalk. Premise as an exterior treatment in conjunction with Premise foam for interior application afforded quick and continued structural protection to the study homes.

THE IMPACT OF IMIDACLOPRID ON SUBTERRANEAN TERMITE COLONIES LOCATED INSIDE AND AROUND RESIDENTIAL STRUCTURES IN CENTRAL NORTH CAROLINA

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There is increasing evidence showing that imidacloprid, the active ingredient of Premise® termiticide, is transferred between individual termites (Thorne and Breish 2001; Shelton and Grace 2003, Tomalski and Vargo, unpublished) and that effects on the colony can be far reaching beyond the treatment area (Osbrink and Lax 2003). This study in central North Carolina makes use of DNA technology and long term monitoring to observe the immediate and long term effects of imidacloprid on subterranean termites, *Reticulitermes* spp., colonies located inside and around residential structures. Four termite-infested houses in Raleigh, NC with active and accessible termites inside each building have been selected and placed into a multi-year monitoring program. An extensive gridwork of soil monitors in the yard and wooden stakes under crawlspace houses were used to monitor termites at monthly intervals for at least 6 months before

treatment in order to develop a stable map of termite activity. Interior infestations were also sampled but on a less frequent basis in order to minimize disturbance to the termites inside the structure. A licensed PMP applied Premise® 75WSP at 0.05% to each house by trenching and rodding around the outside of the foundation, and in two cases making a limited interior application.

Termite samples collected from each soil monitor and from inside each structure were genotyped at several microsatellite loci using established methods (Vargo 2003a, b). Microsatellite DNA markers are particularly useful for “fingerprinting” colonies, providing a powerful means to distinguish workers belonging to different colonies and to delineate colony foraging areas (Vargo 2003a, b; DeHeer and Vargo 2004). A long term comparison of genotypes of workers present before and after treatment is being used to assess the impact of imidacloprid on the original termite colonies present at each site. Over time, we will be able to determine whether any of the original colonies attacking the structures are able to recover and reappear near the buildings after imidacloprid treatment, or whether they disappear from the area, presumably because they were eliminated.

High levels of termite activity were found prior to treatment at each property with soil monitor hit rates of 5 - 18%. Nearly all samples consisted of *R. flavipes* with only a couple samples of *R. virginicus* detected. Genetic analysis showed multiple subterranean termite colonies at all properties with up to eight colonies observed at one site, and up to two colonies infesting a structure simultaneously. Termite colonies inside buildings were also picked up in soil monitors located at distances of 1.5 - 28 ft. from the foundation wall.

The application of imidacloprid (Premise® 75WSP) at 0.05% as a perimeter only or as a perimeter plus limited interior treatment resulted in a rapid decline of termites inside each building with complete elimination of all known interior infestations within 7 - 85 days. The structure requiring 85 days for elimination was characterized by excessive moisture at the time of application which prevented treatment to one side of an interior foundation wall separating two of the units in a four unit apartment complex. Termites in the shelter tube at that site showed clear symptoms of imidacloprid poisoning and were moving slowly one week before activity ceased.

Termite activity in the soil monitors placed along the foundation and in the yard of each property were also severely impacted following imidacloprid treatment. In fact all active monitors at every test site became inactive 21 - 80 days after treatment, even those located 17 - 50 ft. from the foundation wall. It was even observed that termite colonies detected in the outer ring of monitors, and distinct from colonies inside the structure, also disappeared following treatment.

These early results show that in central North Carolina there can be numerous subterranean termite colonies in close proximity to structures, and that attacks on

a single house can come from multiple colonies. Imidacloprid application resulted in quick elimination of termite activity inside and outside the buildings with wide ranging effects on colonies up to 50 ft. away from the treatment area. Long-term monitoring and microsatellite genotyping over the next 2-3 years will provide the best assessment of elimination by imidacloprid of the original termite colonies that were present at each site.

References:

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- Osbrink, W. and A. Lax. 2003. Effect of imidacloprid tree treatments on the occurrence of Formosan subterranean termites, *Coptotermes formosanus* Shiraki (Isoptera: Rhinotermitidae), in independent monitors. *Journal of Economic Entomology* 96: 117-125.
- Shelton, T. G. and K. G. Grace 2003. Effects of exposure duration on transfer of nonrepellent termiticides among workers of *Coptotermes formosanus* Shiraki (Isoptera : Rhinotermitidae). *Journal of Economic Entomology* 96: 456-460.
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- Vargo, E. L. 2003a. Genetic structure of *Reticulitermes flavipes* and *R. virginicus* (Isoptera: Rhinotermitidae) colonies in an urban habitat and tracking of colonies following treatment with hexaflumuron bait. *Environmental Entomology* 32: 1271-1282.
- Vargo, E. L. 2003b. Hierarchical analysis of colony and population genetic structure of the eastern subterranean termite, *Reticulitermes flavipes*, using two classes of molecular genetic markers. *Evolution* 57: 2805-2818.

FIELD EFFICACY OF FIPRONIL AS AN EXTERIOR PERIMETER TREATMENT AGAINST *RETICULITERMES FLAVIPES* IN OHIO

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Fipronil (Termidor®) was evaluated at three concentrations (0.06%, 0.09%, and 0.125%) against structural infestations of the eastern subterranean termite, *Reticulitermes flavipes*, in Ohio. Studies were initiated in 2000, 2001, and 2002. A total of nine structures were treated along the exterior only, and one structure additionally was spot treated at several interior sites (non-label use patterns). The majority of these structures had a complete or partial basement. In conjunction with interior inspections, wooden monitors placed around the perimeter of each structure and outside of the treated zone were inspected after

3 months and then at yearly intervals post-treatment. There was no evidence of termite activity in any structure 3 months after treatment, although termites were found in some wooden monitors at three structures. At the 1-, 2-, or 3-year inspection periods, no evidence of termite activity was found indoors and all wooden monitors around the perimeter were devoid of termites. Furthermore, residents have reported the absence of termite swarmers. Termidor® has provided excellent protection of these structures in Ohio for 1-3 years and studies are continuing.

PROGRESS OF RESEARCH ON THE NOVEL PROTEINS FROM THE FRONTAL GLAND OF FORMOSAN TERMITES- FROM DISCOVERY TO GENE CLONING AND EXPRESSION

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The Formosan subterranean termite, *Coptotermes formosanus* Shiraki, is the most destructive subterranean termite pest in the U.S. The soldier of the *Coptotermes formosanus* possesses a frontal gland which was supposed to function as defence. Here we show our discovery of seven different molecular weight of novel proteins from the secretion of the frontal gland as in Fig.1

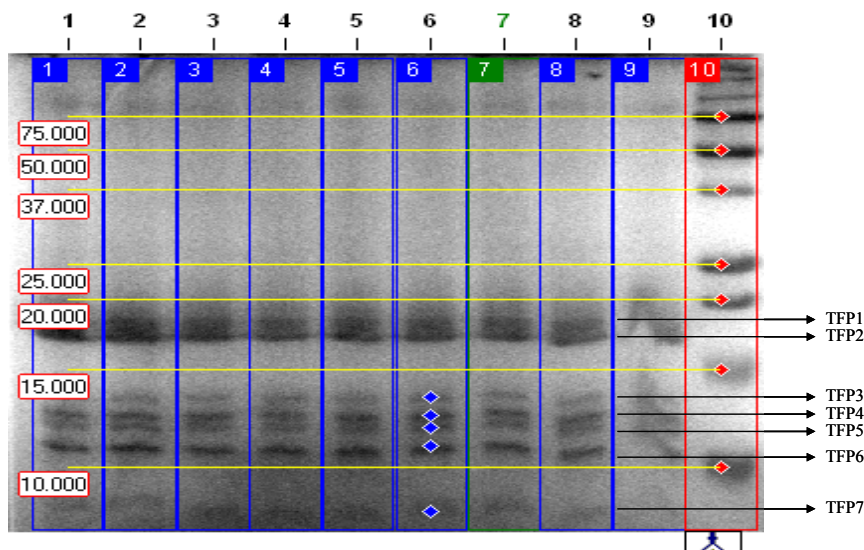
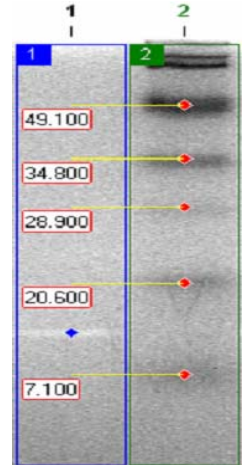


Fig.1. 10 μ l of Precision Plus Prestained Standards from Bio-Rad was loaded in the well of lane 10; 10 μ l of 18mg/ml sample from frontal gland secretion was loaded in the well of lane1-9. In the SDS-PAGE image, it showed there are 7 proteins in the frontal gland secretion. All of the seven different molecular weight of proteins are rich in cysteine and have lower pI value less than 5.0.

We detected lysozyme activity of the protein TFP 4 and TFP5 by zymogram method (Hardt et al. 2003; Fig. 2).

Fig. 2. Molecular weight of the novel lysozyme from *Coptotermes Formosanus* In this SDS-PAGE gel containing 0.06% Rymazol blue-stained *M.lysodeikticus* cells, 10 ug of 4mg/ml frontal gland sample was loaded in Lane 1; 10ul of Broad-Range prestained standards from Bio-Rad was loaded in Lane 2. The Molecular Weight of the novel lysozyme was calculated with the software Total-Lab as 11.3 Kd.



We sequenced the N-terminal of the protein TFP4 and TFP5, because protein TFP4 and TFP 5 have same N-Terminal sequence they might be the same protein but have different conformation. Based on the sequence we have successfully cloned the gene with RACE and over expressed it with recombinant plasmid pET 41a+ MLE in BL21 DE3 as in Fig.3

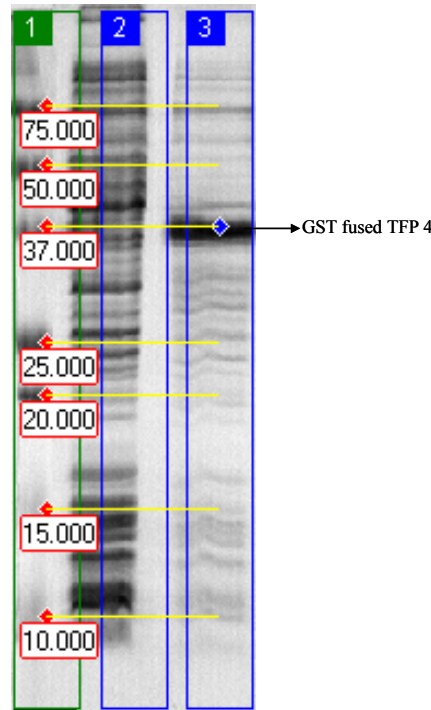


Fig.3. Lane1: Prestained Standards; Lane 2: Whole protein from BL21 DE3 without IPTG induction; Lane3: Whole protein from BL21 DE3 with IPTG induction.

Reference:

Hardt, M., Y. Guo, G. Henderson and R. A. Laine. 2003. Zymogram with Remazol-brilliant-blue labeled *Micrococcus lysodeikticus* cells for the detection of lysozymes : example of a new lysozyme activity in Formosan termite defense secretions. Anal. Biochem. 312:73-6.

2004 National Conference on Urban Entomology Planning Committee

Daniel Suiter (University of Georgia), Conference Chair

Paul Baker (University of Arizona), Local Arrangements

Robert Kopanic (S.C. Johnson), Program and Proceedings Co-Chair

Dini Miller (Virginia Tech University), Program and Proceedings Co-Chair

Roger Gold (Texas A&M University), Secretary/Treasurer

Gary Bennett (Purdue University), Sponsorship Co-Chair

Bill McClellan (DuPont), Sponsorship Co-Chair

Shripat Kamble (University of Nebraska), Awards Chair

Barbara Thorne (University of Maryland), Awards

Robert Davis (BASF), Awards

2004 NCUE Closing Business Meeting Minutes
Saturday, May 22
12:45-2:00 p.m., Regency B
Hyatt Regency, Phoenix, AZ

Called to order at 12:45pm

Present: Committee members: Roger Gold, Dan Suiter, Dini Miller, Laura Nelson, Bob Kopanic, Shripat Kamble, Paul Baker, and at least 10-15 other participants.

Discussion/review of 2004 conference:

Suggestions received from conference attendees:

While the conference is underway, have a desk copy of the name and addresses of people who are attending for other people at the conference who might want to know who else is attending, and get together with them for dinner, etc.

Consider offering CEU's from various states to attract PMP's to the meetings.

Have commercial exhibitors (books, etc.)

Sell products such as t-shirts, ties, etc.

Have a debate-type of forum, where discussions are encouraged.

Improve possible advertisement sources from Fumigants and Phermones newsletter.

Dini Miller volunteered to compile and print the proceedings. Laura will send her the envelopes and mailing labels ready to go.

Future meetings should start on Sunday evening and go through to Wed or Thur.

Expenses still to be paid:

Hyatt balance (after the 25K deposit)

S.C. Johnson, approx. \$1900, for program printing

Buses, \$675

Desert Botanical Gardens, \$250

Cost of printing and mailing for proceedings

Travel costs to be paid for the Mallis Lecturer (Roger Gold)

Registration personnel (Laura Nelson, and Mark Wright)

2006 committee members will be:

Conf. Co-Chairs: Bob Kopanic and Dini Miller

Local Arrangements: Jules Silverman and Mark Coffelt

Program and Proceedings: Linda Hooper-Bui and Bob Cartwright

Sponsorship: Gary Bennett, Bill McClellan, John Paige, and Shripat Kamble

Treasurer: Roger Gold

Awards: Bob Davis, Mike Merchant, Dan Suiter

A change for 2006 will involve scholarships. At least three \$1500 scholarships will be awarded, for Ph.D., M.S., and undergraduate, and it will be delineated as \$1000 for the actual scholarship and \$500 for travel. The decision deadline will be moved earlier in the year to allow time for the recipients to make travel arrangements, etc. The number of recipients will be determined by the amount of money in the treasury. Following a discussion, it was decided that the students would continue to pay a "student" registration fee.

Meeting time of year for 2006? It was determined that the meeting will continue to be held on the 3rd or 4th week in May (to not conflict with final exams), with the welcome reception being held on Sunday evening. It should be noted that the closing session had approx. 125 people, which was the highest on record.

Future of NCUE: There was a unanimous decision to continue the conference at least through 2008. It is one of the few opportunities to merge industry and academia.

Meeting Format: This year's format of invited papers and symposia worked well. It was suggested that a debate format be attempted and that more time be allowed for discussion of pertinent topics. Concerns continued over concurrent sessions; however, keeping the sessions on time avoided much of the complaint. Comments were made to possibly include poster presentations.

The evaluations of the 2004 NCUE:

Review attachment. Some specific comments that may help the planners in the future include the following:

According to the evaluations, this was one of the most successful meetings that has been held.

Receptions and outings should be more specific as to the schedule and cost of the activity including "open/cash bar". It was suggested that one "free" beverage ticket be issued with each paid registration for each event.

Provide a greater variety of foods for meals and breaks.

Mallis Award Lecture to be given at the discretion of the speaker.
Awards lunch: No invocation.

There were concerns that the student presenters may need to be better prepared for their presentations.

Desert Botanical Gardens trip was very expensive. There were some concerns that Garden representatives were not present to conduct tours, etc.

Overall, the breaks were the right length, etc. The registration, organization and staff were appreciated. Registration fee was "just right". There were some reported problems with the brochure in terms of size, accuracy of information, and usage. It might be necessary to purchase ads in industry ads to boost registration in the future. An effort should be made to attract and invite PMPs, especially those from the local area where the meeting is held.

New Business:

The site for 2006 will be in Raleigh/Durham, NC. It was further suggested that the 2008 conference be held in New Orleans, with sponsorship being provided by USDA Formosan termite project.

John Paige volunteered and will be added to the Sponsor Committee.

Meeting was adjourned at 2:00pm.

2006 National Conference on Urban Entomology Planning Committee

Robert Kopanic (S.C. Johnson), Conference Co-Chair

Dini Miller (Virginia Tech), Conference Co-Chair

Linda Hooper-Bui (LSU), Program and Proceedings

Bob Cartwright (Syngenta), Program and Proceedings

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

Gary Bennett (Purdue University), Sponsorship Co-Chair

Bill McClellan (DuPont), Sponsorship Co-Chair

Shripat Kamble (University of Nebraska), Sponsorship Co-Chair

John Paige (Bayer), Sponsorship Co-Chair

Bob Davis (BASF), Awards

Mike Merchant (Texas A&M Dallas), Awards

Daniel Suiter (University of Georgia), Awards

Jules Silverman (North Carolina State University), Local Arrangements Co-Chair

Mark Coffelt (BASF), Local Arrangements Co-Chair

Distinguished Achievement Award Recipients

- 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

NCUE Conference Chairs

- 1986 William H. Robinson, Virginia Polytechnic Institute & State University
February 24-27
College Park, MD
- 1988 Patricia A. Zungoli, Clemson University
February 21-24
College Park, MD
- 1990 Michael K. Rust, University of California, Riverside
February 25-28
College Park, MD
- 1992 Gary W. Bennett, Purdue University
February 23-26
College Park, MD
- 1994 Judy K. Bertholf, DowElanco
Roger E. Gold, Texas A&M University
February 20-22
Atlanta, GA
- 1996 Donald A. Reiersen, University of California, Riverside
February 18-20
Arlington, TX
- 1998 Arthur Appel, Auburn University
April 26-28
San Diego, CA
- 2000 Shripat T. Kamble, University of Nebraska
May 14-16
Fort Lauderdale, FL
- 2004 Daniel R. Suiter, University of Georgia
May 20-22
Phoenix, AZ

List of Attendees

2004 National Conference on Urban Entomology

May 20-22, 2004

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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.

Thompson, Derrig & Craig, P.C.

CERTIFIED PUBLIC ACCOUNTANTS

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August 15, 2003

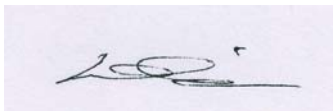
National Conference of Urban Entomology
Board of Directors' Members
C/o Texas A&M University
Center for Urban and Structural Entomology
College Station, TX 77843-2475

The last tax return (IRS Form 990) we prepared for the National Conference of Urban Entomology was for the 1999 year. For the 2000, 2001, and 2002 years, no return has been required based on the average gross receipts for each of these years. The IRS generally requires a return to be filed by a not for profit organization only when the average gross receipts over a three year period are more than \$25,000. Therefore, the organization is currently in compliance with IRS filing requirements.

We have received the bank statements for 2000, 2001 and 2002. We checked the bank account activity and found no unusual or unreasonable transactions based on the knowledge we have of the organization's activities. We did not perform an audit, nor did we perform procedures that could detect fraud. However based on the services performed, we found no transactions which we believe should be addressed in this letter.

We appreciate your business and look forward to working with you in the future. Please contact us if any additional information would be helpful.

Sincerely,



Andrea Derrig, CPA