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# 1998 NATIONAL CONFERENCE ON URBAN ENTOMOLOGY

Kona Kai Continental Plaza Resort & Marina Hotel  
San Diego, California

## SUNDAY, April 26

8:00 am Registration - Ballroom Foyer

10:00 am Welcome - Point Loma 2 & 3  
Arthur Appel, Conference **Chair** - Department of Entomology, Auburn University, Auburn, AL

10:15 - 11:00 am "Spiders and mankind: The ultimate lovelove relationship" - Mark Lacey, Terminix International, 1800 Marshall Ave., Wilmington, DE

11:00 am - 12:00 pm Arnold Mallis Memorial Award **Lecture**  
"Cockroach **Management** - Progress and Prospects" - Gary Bennett, Department of Entomology, Purdue University, West Lafayette, IN

12:00 pm - 5:30 pm San Diego excursions - on your own

5:30 - 8:00 pm San Diego Harbor Cruise  
Boat boards at the Kona Kai Marina dock at 5:30 pm

## MONDAY, April 27

8:00 am Refreshments (coffee/juice) - Foyer

8:30 - 9:15 am - Point Loma 2  
"Insect-fungal Interactions" - Dr. Ion BOLLICIAS, Department of Entomology, University of Florida, Gainesville, FL

9:15 - 10:00 am "Biological Control by Natural Enemies in Interior Landscapes and Model Systems" - Michael Rose, Research Entomologist, Montana State University, Bozeman, MT

10:00 - 10:20 am Break

10:20 - 10:30 am Important Announcements on Urban Entomology - William Robinson & Robert Corrigan

10:30 - 11:15 am "Emerging Arthropod-Borne Diseases in Urban Environments" - James Olson, Viral and Rickettsial Zoonoses Branch, Centers for Disease Control and Prevention, Atlanta, GA

11:15 - 12:00 pm "Ethical Considerations in Extension, Research, and Industry Programs" - Roger Gold, Department of Entomology, Texas A&M University, College Station, TX

12:00 - 2:00 pm Lunch (on your own)

2:00 - 5:00 pm CONCURRENT PAPER SESSIONS

- TERMITES - Point Lorna 2
- COCKROACHES AND FLEAS - Point Lorna 3

6:00 - 8:00 pm Mixer on the beach (no host bar)

TIJESDAY, April 28 - Point Lorna 2

9:00 - 9:30 am "Quality control in the pest control industry: Why and How." - Jim Wright, Department of Entomology, Clemson University, Clemson, SC

9:30 - 10:00 am "An anecdotal history of the Formosan subterranean termite in Hawaii," - Minoru Tamashiro, Department of Entomology, University of Hawaii, Honolulu, HI

10:00 - 10:30 am Break

10:30 - 12:00 N CONCURRENT PAPER SESSIONS

- MONITORING, SURVEILLANCE, PERIMETER PESTS, STORED PRODUCTS -  
Point Lorna 3
- ROLE OF EXTENSION SPECIALISTS AND CONSULTANTS IN URBAN ENVIRONMENTS  
- Coronado
- NEW AND EMERGING TECHNOLOGIES - Point Lorna 1

12:00 - 1:30 pm - Point Lorna 2

Conference Luncheon (provided)

1:30 - 3:00 pm CONCURRENT PAPER SESSIONS

- TERMITES - Point Lorna 3
- ANTS - Point Lorna 1

3:00 - 3:30 pm Break

3:30 - 4:30 pm - Point Lorna 2

- ETHICS AND URBAN ENTOMOLOGY: A TO HALL MEETING

Moderator: Michael Potter, Department of Entomology, University of Kentucky, Lexington, KY

4:30 - 5:00 pm - Point Lorna 2

Business Meeting

MONDAY, April 27

2:00 - 5:00 pm - Point Lorna 2

- TERMITES

Moderator: J. Kenneth Grace, Department of Entomology, University of Hawaii, Honolulu, HI

2:00 - 2:15 pm "Seasonal changes in foraging activity and abundance of two species of subterranean termites in the genus *Reticulitermes* (Isoptera: Rhinotermitidae)." Richard M. Houseman and Roger E. Gold, Department of Entomology, Texas A&M University, College Station, TX 77843.

2:15 - 2:30 pm "Temperature affects on caste differentiation of three subterranean termites in the genus *Reticulitermes* (Isoptera: Rhinotermitidae)." Thomas E. Macom, Barry M. Pawson, and Roger E. Gold, Department of Entomology, Texas A&M University, College Station, TX 77843.

2:30 - 2:45 pm "Seasonal foraging behavior of *Reticulitermes* spp. in northern California." Gail M. Getty, Michael I. Haverty, Kirsten A. Copern, and Vernard R. Lewis, USDA Forest Service, Pacific Southwest Research Station, P.O. Box 245, Berkeley, CA 94701.

- 2:45 - 3:00 pm "Size and distribution of *Reticulitermes* colonies in a wildland and residential location in northern California." Michael L. Haverty, Gail M. Getty, Vernard R. Lewis, and Kirsten A. Copern, USDA Forest Service, Pacific Southwest Research Station, P.O. Box 245, Berkeley, CA 94701.
- 3:00 - 3:15 pm "Mark-recapture with the Fonnosan subterranean termite to study the movement of foragers among feeding sites." Nan-Yao Su and Michael L. Haverty, University of Florida, Ft. Lauderdale Research and Education Center, 3205 College Ave., Ft. Lauderdale, FL 33314.
- 3:15 - 3:30 pm "Comparisons of single and group bioassays on attraction and arrestment of *Reticulitermes* spp. (Isoptera: Rhinotermitidae) to selected cellulosic materials." Steven R. Suoja, Vernard R. Lewis, David L. Wood, and Myles Wilson, Division of Insect Biology, DESPM, 201 Wellman Hall, University of California, Berkeley, CA 94720.
- 3:30 - 3:45 pm "The art of above-ground baiting of *Coptotermes formosanus* Shiraki with Recruit AG station". Julian R. Yates and J. Kenneth Grace, Department of Entomology, University of Hawaii, Gilmore Hall 3050, Maile Way, Honolulu, HI 96822.
- 3:45 - 4:00 pm "Wood consumption and fecal pellet production by two drywood termites (*Kalotermitidae*)." J. Kenneth Grace and R.T. Yamamoto, Department of Entomology, University of Hawaii, Gilmore Hall, 3050 Maile Way, Honolulu, HI 96822.
- 4:00 - 4:15 pm "Laboratory evaluation of microwaves for controlling the western drywood termite (Isoptera: Kalotermitidae)". Vernard R. Lewis, Michael L. Haverty, and Ariel Power, Division of Insect Biology, DESPM, 201 Wellman Hall, University of California, Berkeley, CA 94720.
- 4:15 - 4:30 pm "Injection of Spinosad SC for the control of *Cryptotermes brevis* in hardwood shipping pallets." R. Joseph Woodrow and J. Kenneth Grace, Department of Entomology, Gilmore Hall, 3050 Maile Way, Honolulu, HI 96822.
- 4:30 - 4:45 pm "Prevention of drywood termite infestation with disodium octaborate tetrahydrate." Rudolf H. Scheffrahn, Nan-Yao Su, Jan Krecek, Boudanath Maharajh, and Gregory Wheeler, University of Florida, Ft. Lauderdale Research and Education Center, 3205 College Ave., Ft. Lauderdale, FL 33314.
- 4:45 - 5:00 pm "Control of western drywood termites (*Incisitermes minor*, Hagen) with Spinosad in California, 1996. Robert E. Williams, Ellen M. Thoms, and D. Michael Chambers. Dow Agrosciences, 1997. Moorpark, CA.

#### MONDAY, April 27

2:00 - 5:00 pm - Point Loma 3

#### ➤ COCKROACHES AND FLEAS

Moderator: William Robinson, Department of Entomology, Virginia Polytechnic Institute & State University, Blacksburg, VA

- 2:00 - 2:15 pm "Selective thermal control of German cockroaches using spatial analysis to identify population foci". Brian C. Zeicher and Alfred I. Hoch. U.S. Army CHPPM, Aberdeen Proving Ground, MD 21010.
- 2:15 - 2:30 pm "Trapping cockroaches: where do we put traps and how many do we need?" Lane M. Smith and Arthur G. Appel, Department of Entomology, Auburn University, AL 36849.
- 2:30 - 2:45 pm "Daily trap-catch dynamics of German cockroach (Dictyoptera: Blattellidae) in kitchens." Arthur G. Appel, Department of Entomology, Auburn University, AL 36849.



- 2:45 - 3:00 pm "Smokybrown cockroaches and their environment: trees, bushes, ground cover, man-made structure, and spatial effects." Lane M. Smith and Arthur G. Appel, Department of Entomology, Auburn University, AL 36849.
- 3:00 - 3:15 pm "Cockroach IPM: Fact or fiction?" Mike S. Chapman, Western Exterminators, Irvine, CA 92714.
- 3:15 - 3:30 pm "Pathogenicity of *Metarhizium anisopliae* strain esc-1 to Gennan cockroaches and its compatibility with insecticides." Pari Pachamuthu and Shripat T. Kamble, Department of Entomology, University of Nebraska, Lincoln, NE 68583
- 3:30 - 3:45 pm "The rapid emergence of resistance to certain insecticides in the Gennan cockroach." Donald G. Cochran, Professor Emeritus, Department of Entomology, Virginia Polytechnic Institute & State University, Blacksburg, VA 24061 .
- 3:45 - 4:00 pm "Relationship between insecticide resistance level and detoxication enzyme activity in the German cockroach: Can surrogate substrates be used to detect resistance?" Steven M. Valles, USDA-ARS, Center for Medical, Agricultural and Veterinary Entomology, Gainesville, FL 32608.
- 4:00 - 4:15 pm "Comparison of esterases between resistant Crawford and susceptible CSMA strains of German cockroach (Diptera: Blattellidae)." No-Jong J. Park and Shripat T. Kamble, Department of Entomology, University of Nebraska, Lincoln, NE 68583.
- 4:15 - 4:30 pm "Juvenile hormone: Regulator of feeding and reproduction in cockroaches." Glenn L. Holbrook and Coby Schal, Department of Entomology, North Carolina State University, Raleigh, NC 27695.
- 4:30 - 4:45 pm "Plagued by Fleas: A closer look at the California ground squirrel." Marco E. Metzger and M. K. Rust, Department of Entomology, University of California, Riverside, CA 92521.
- 4:45 - 5:00 pm "Absence of systemic activity in pyriproxyfen fed fleas." Roger Meola, Kristin Meier, and Susan Dean, Department of Entomology, Texas A&M University, College Station, TX 77843.

## TUESDAY, April 28

10:30 am - 12:00 pm - Point Lorna 3

### ➤ MONITORING, SURVEILLANCE, PERIMETER PESTS, STORED PRODUCTS

Moderator: Karen Vail, Extension Entomology, University of Tennessee, Knoxville, TN

- 10:30 - 10:45 am "Daily and seasonal variations in soil temperatures around structures with slab foundations." Harry N. Howell Jr. and Roger E. Gold, Department of Entomology, Texas A&M University, College Station, TX 77843.
- 10:45 - 11:00 am "Evaluation of efficacy and residues of cypenethrin and penethrin used in field tests on structures in Texas". Mark S. Wright, Roger E. Gold, and Harry N. Howell, Jr., Department of Entomology, Texas A&M University, College Station, TX 77843.
- 11:00 - 11:15 am "Analysis of soil properties in relation to termiticide performance in Louisiana." Gregg Henderson, P. Mark Walthall, Beverly A. Witz, Victor H. Rivera-Monroy, David R. Ganaway, and H. Magdi Selim, Louisiana State University Agriculture Center, Baton Rouge, LA 70803.
- 11:15 - 11:30 am "Fauna found within in-ground subterranean termite monitoring and bait stations in southern California and their impact on termite control." Hanif Gulmabamad, Terminix International, 1501 Harris Court, Anaheim, CA 92806.

11:30 - 11:44 am "Using population mapping and contributing environmental factors to characterize pest **populations** as a basis for pest management decisions in field **situations**." Jeffery Weier, Sprague Pest Control Specialist, 2139 South Fawcett Ave., Tacoma, WA 98041.

11:45 - 12:00 pm "Monitoring with sugar water to determine the efficacy of treatments to control Argentine ants, *Linepithema humile* (Mayr)." Donald A. Reiersen, **MK Rust**, and I. Hampton-Beesley, Department of Entomology, University of California, Riverside, CA 92521.

TUESDAY, April 28

10:30 am - 12:00 pm - Coronado

➤ **ROLE OF EXTENSION SPECIALISTS AND CONSULTANTS  
IN URBAN ENVIRONMENTS**

Moderator: George **Rambo**, G. Rambo, Consulting Services, Inc. Herndon, VA

10:30 - 10:45 am "The balancing act: Expectations of extension specialists with urban responsibilities." Faith M. Oi, Auburn University, Department of Entomology and Alabama Cooperative Extension System, Auburn, AL 36849.

10:45 - 11:00 am "The role of extension specialists in dealing with delusory parasitosis." Nancy C. Hinkle, Department of Entomology, University of California, Riverside, CA 92521.

11:00 - 11:15 am "South Carolina master tennite technician training: Linking extension education and pesticide regulation to meet state compliance standards for subterranean tennite treatments" Eric P. Benson, Neil J. Ogg, James Wright, and Elizabeth M. Kane, Department of Entomology, Clemson University, 113 Long Hall, Clemson, SC 29634.

11:15 - 11:30 am "Role of NPCA in providing technical assistance to the pest control operator." Greg Baumann. National Pest Control Association, 8100 Oak St., Dunn Loring, VA 22027.

11:30 - 11:45 am Problems in subterranean tennite technology transfer, commercial speech, and control practices. Bill J. Hawks, Jr., Bionergics, PO Box 412, Wichita, KS 67201

11:45 - 12:00 pm "A summary of **Recruit** AG trials and station placement in conjunction with acoustic emission counts in the northeastern U.S." George Rambo and J.D. Thomas, Dow Agrosciences, 5 Bel Air South Parkway, Suite 109, Bel Air, MD 21015.

TUESDAY, April 28

10:30 am - 12:00 pm - Point Loma 1

➤ **NEW AND EMERGING TECHNOLOGIES**

Moderator: Patricia Zungoli, Department of Entomology, Clemson University, Clemson, SC

10:30 - 10:45 am "Phylogenetic diversity and geographic structure of sympatric species of Reticulitermes (Isoptera: Rhinotermitidae): A maternal perspective." Tracie M. Jenkins and Brian T. Forschler, Department of Entomology, University of Georgia, Athens, GA 30602

10:45 - 11:00 am "Using genetic **markers** to distinguish Australian *Coptotermes acinaciformis* (Froggatt) (Isoptera: Rhinotermitidae)." Jiasi Wang and I. Kenneth Grace, Department of Entomology, Gilmore Hall, 3050 Maile Way, Honolulu, HI 96822.

11:00 - 11:15 am "Characterization of Cytochrome P450 Monooxygenases in the dark southern subterranean tennite, *Reticulitermes virginicus*." Steven M. Valles, Weste Osbrink, and Richard I. Brenner, USDA-ARS, Center for Medical, Agricultural and Veterinary Entomology, Gainesville, FL 32608.

11:15 - 11:30 am "Laboratory examination of Bio-BlasU biological termiticide against *Reticulitermes* spp. (Isoptera: Rhinotermitidae)." Brian T. Forschler and Veronica Jelks, Department of Entomology, University of Georgia, Athens, GA 30602.

11:30 - 11:45 am "Survival of varying densities of two species of unfed subterranean termites exposed to a fixed number of hexaflumuron-fed cohorts (Isoptera: Rhinotermitidae)." Kristen G. van den Meiracker, Patricia A. Zungoli, Eric P. Benson, and William C. Bridges, Department of Entomology, Clemson University, Clemson, SC 29634.

11:45 - 12:00 pm "Chlorfenapyr: A new insecticide for urban pest management." Byron L. Reid and Robert A. Farlow, American Cyanamid Company, P.O. Box 400, Princeton, NJ 08543.

TIJESDAY, April 28

1:30 - 3:30 pm - Point Loma 3

➤ TERMITES

Moderator: Nan-Yao Su, University of Florida, Ft. Lauderdale Research and Education Center, Ft. Lauderdale, FL

3:30 - 1:45 pm "Control of structural infestation Of *Heferofennes aureus* in Arizona with Sentricon colony elimination system." Thomas H. **Atkinson**, Michelle M. Smith, and Robert E. Williams, Dow Agrosciences, Indianapolis, IN 46268.

1:45 - 2:00 pm "Systematic termite control ... Results from the real world." James B. Ballard. FMC Specialty Products, Philadelphia, PA 19103.

2:00 - 2:15 pm "Field and laboratory tests of suffluramid treated cardboard and FirstlineJ termite baits." Brian T. Forschler and Erica Chiao, Department of Entomology, University of Georgia, Athens, GA 30602.

2:15 - 2:30 pm "Laboratory and field evaluations of FirstlineJ Bait System in IPM Programs." RE. **Gold**, R.M. Houseman, and H.N. Howell, Jr., Department of Entomology, Texas A&M University, College Station, TX 77843.

2:30 - 2:45 pm "Baiting technology for subterranean termite control." Shripat T. **Kamble** and James W. Austin, Department of Entomology, University of Nebraska, **Lincoln**, NE 68583.

2:45 - 3:00 pm "Protection of historical and artistic structures in Italy against subterranean termite *Reficulifermes lucifugus* (Isoptera: Rhinotermitidae) by means of hexaflumuron baits." Roberto Ferrari, Jean-Louis Leca, **Mario** Marini, and Valeria Zaffagini, Tecnic Scientific Service Sireb - Str. Collegara n02711-41010 Modena, Italy

TIJESDAY, April 28

1:30 - 3:00 pm - Point Loma 1

➤ ANTS

Moderator: John Klotz, Department of Entomology, University of California, Riverside, CA

1:30 - 1:45 pm "A new bait attractive to multiple species of ants." David F. Williams, Karen M. Vail, and David H. Oi, USDA-ARS, Center for Medical, Agricultural, and Veterinary Entomology, 1600 SW 23rd Dr., Gainesville, FL 32608.

1:45 - 2:00 pm "Food flow and trophallaxis among Argentine ants, *Linepifhema humile* (Mayr)." Michael K Rust and Linda M. Hooper, Department of Entomology, University of California, Riverside, CA 92521.

- 2:00 - 2:15 pm    “**The** effect of hydramethylnon and fipronil on food flow among Argentine ants, *Linepithema humile* (Mayr).” Linda M. Hooper and Michael K. Rust, Department of Entomology, University of California, Riverside, CA 92521.
- 2:15 - 2:30 pm    “**Ant** pheromones as attractants and repellents for Argentine ants.” **Les** Greenberg and John Klotz, Department of Entomology, University of California, Riverside, CA 92521.
- 2:30 - 2:45 pm    “*Solenopsis invicta* (Buren) mounds as *Reticulitermes* spp. habitats.” Thomas G. Shelton, J.T. Vogt, A.G. Appel, and F.M. Oi, Department of Entomology, Auburn University, AL 36849.
- 2:45 - 3:00 pm    “**Red** imported fire ant, *Solenopsis invicta* (Buren), flight energetics.” J.T. Vogt and A.G. Appel, Department of Entomology, Auburn University, AL 36849.

# 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 biannually. 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 give or prepared at the biannual meeting.
4. To promote scholarship and the exchange of ideas among urban entomologists.
5. ~~As~~ funds are available to provide scholarships to students working in urban entomology.

### 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 is 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 seeking 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 in 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 manufactures 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 biannual 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 replacement 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:

Conference Steering Committee-Composed of the seven officers as described above, and chaired  
by the Chair of the Conference.

Nomination Committee: Chaired by Chair of Conference Committee

Program Committee: Chaired by Chair of Program Committee

Sponsorship Committee: Chaired by Chair of Sponsorship Committee  
Awards Committee: Chaired by Chair of Awards Committee  
Local Arrangements Committee Chaired by Chair for Local Arrangements  
Industry Representative Committee: Chaired by Industry Representative Committee.  
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 biannual 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 of 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 or each year.

#### ARTICLE XII-AMENDMENTS

The bylaws for this organization may be amended by a two-thirds affirmative vote of the attendees at the biannual 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 of 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 detennines 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 fonn and/or reimbursement by the organization.



## LITTLE MISS MUFFET, ARACHNE AND THE ENTOMOLOGIST: SPIDERS IN HISTORY, IN LORE AND IN REALITY

Dr. Mark S. Lacey  
Terminix International  
1800 Marshall Avenue  
Wilmington, DE

Spiders have been inextricably linked to mankind for thousands of years. They are the rarest of creatures having the ability to evoke fear, **fascination**, wonder, and even **admiration**, simultaneously. They are a living paradox, providing immeasurable benefits yet often producing nearly unbearable pain and anguish. Perhaps no other group of animals is so completely woven into the fabric of our lives. Like the many disciplines of entomology, their impact is a varied yet intricately woven quilt where each piece is separate yet instrumental in forming the whole.

### Spider Ancestors

Though insects represent the most diverse and numerically dominant group of terrestrial arthropods **known**, with well over a million currently described species, spiders are a distant second with about 35,000 described species. They are an ancient group, which appear to have evolved from the Palaeocharinids, a family of the extinct arachnid order Trigonotarbita. Evidence indicates that the earliest true spiders evolved between 380 and 400 million years ago in the land mass that subsequently split to form what are now North America and Europe.

### Arachnophobia

The success of the movie Arachnophobia was due in no small part to the "fear factor" - that strange but not uncommon characteristic of **humans** that makes them want to be led to the brink of sheer terror only to be able to step back in relief with the realization that no true harm **has** befallen them. To some people, however, the fear of spiders can be a debilitating malady that can render them both physically and psychologically ill. Numerous surveys identify spiders as one of the most feared creatures on the face of the earth. Most list them in the top two along with snakes. There may be several reasons for this almost-ingrained fear. First, is the deliberate movement of eight legs that seem capable of sending the spider in any direction, at any time. Whether it's the wolf spider scurrying rapidly across the floor or the slow-deliberate gait of the tarantula, the movement of a spider can send chills up our spine.

The second reason for fearing spiders may be their methods of food acquisition. Spiders are predators and as such, acquire their food in one of three ways: by actively hunting it, by waiting patiently to pounce upon it, or by producing webs to ensnare or entangle it. Regardless of the method employed, the hapless victim generally has our sympathy and often our empathy.

The final reason that many fear spiders is because of the way they dispatch their victims after capturing them. Once the spider captures its prey, it bites and injects a dose of paralyzing and ultimately lethal venom. The injection of venom through the bite of a spider is an event that no one wishes to experience. Though spiders rarely bite humans, the results of such bites can sometimes be devastating.

### Myths and Lore

Although they can raise the hair on the backs of our necks, spiders have also been empowered by many cultures with mythical traits because of their abilities, their cunning, and their skill. They have been viewed as not only menacing; but as magical, mystical, and even miraculous. Nearly every culture has at least one story that tells of such wondrous qualities.

Greek mythology tells of Arachne, a country girl so confident in her weaving ability that she boasted that she was the most magnificent weaver of all, including the goddess Athena herself. Challenged by Athena to a contest, Arachne **won**, and so angered Athena that she fled into the forest and hanged herself. Athena made amends by transforming Arachne's body into a spider and ~~the~~ rope into silk so that this poor **peasant** girl might **weave** for

eternity the most beautiful of webs with the finest of silk. Spiders belong to the class Arachnida - so named in honor of this girl.

The myths of many ancient peoples credit the spider as being the creator of the world. Living in the underworld or in the sky, it evoked a widespread image of a huge mother spider with giant abdomen producing eggs for eternity.

Many Native American cultures see the spider as the original force in nature because of its great weaving skills. The legends of the Pueblo and Navajo people tell of Spider **Woman**, the creator of all. "In the beginning, there was the dark purple light at the dawn of being. Spider Woman spun a line to fonn the east, west, north, and south. Breath entered man at the time of the yellow light. At the time of the red light, **man** proudly faced his creator." Spider **Woman** used the clay of the earth, red, yellow, black and white to create people. To each she attached a thread of silk. This thread was the **gift** of creative wisdom.

Navajo legend also tells of a girl who found a hole in the ground from which smoke came. At the bottom of the hole sat Spider **Woman** spinning a web. She invited the girl inside and taught her to weave blankets and baskets but cautioned her **that** bad luck would befall her unless she always left a hole in the center of each article. To this day, the blankets and baskets of the Navajo have a small hole in deference to Spider **Woman**, the creator of all.

A Cherokee legend tells of how fire came to be. Many, many years ago, the earth was cold and dark. The Indians had no fire with which to stay warm or to cook with. There was a race of giants called The Fire People who had fire. All of the animals got together and decided to steal fire from The Fire People. First went the **bear** because he was the strongest; but he failed. A tiny voice said, "Let me try." It was the spider and they all laughed and said, "You are too small." But each animal tried and failed and still the little spider said., "Let me **try**." Finally, since she was the only one left, they agreed to let her try. She fashioned a **small** clay pot with a lid and put it on her back. Off she went toward the village of The Fire People. She would run a bit then stop. Then she would run a bit more and stop. When she finally reached and ember, she placed it in the clay pot and scurried off.

The Fire People immediately realized that the ember had been stolen and began to look for it. But the little spider would run a little ways and stop, run a little ways and stop until she came to the water's edge. Just as The Fire People were about to catch her, she slipped into the water. The Fire People could not enter but they thought that the water had put out the ember and thus went away. What they didn't know, however, was that the ember had baked the clay pot to be waterproof. So the little spider came out of the water and took the fire to the Indians. This is the Sacred Fire of the Cherokees.

West African legends tell of Anansi the Spider. He is Kwaku Anansi, the heroic trickster "spiderman", and is the central figure in **many** West African stories. He is noble and wise and clever. In one such myth, Anansi asks the sky-god for his stories so that he might share them with the world. But the sky-god asks a great price. He wants brought to him a python, a leopard, a nest of hornets, and an invisible fairy. With the help of his wife Aso, Anansi overcomes each with skill, cunning, and **trickery**, and delivers them to the sky-god. True to his word., the sky-god delivers his stories to **Anansi** to share and thus they **become** known as "Spider Stories."

The spider and its remarkable silk have played an important role in many religions. In Borneo, many tribes worship the spider as a primordial god. In West African mythology, the spider's silk represents an umbilical cord between God and humans. For others, it is a medium for ascending into the heavens. The Polynesians believed that silk formed a ladder that could be climbed to the heavens. The Pima Indians of Mexico believe that the world was created by a spider and is supported by a giant web.

The belief that the spirit of a human passes at death into the body of an **animal** is also widespread. The Chibcha Indians believe that human souls must cross the river of death on rafts made of spider webs. Thus, to kill a spider is to kill a soul. Such beliefs are common in cultures as diverse as West African tribes and the Teton Indians of North America. The Bhils and Mats of India worship them as the recipients of ancestral spirits.

Perhaps some of the most interesting myths and legends are those in which people are protected, hidden and even inspired by spiders. King Robert the Bruce of Scotland, after his defeat by King Edward of England in 1306, took refuge in a cave during a violent storm. **As** he hid, he watched a small spider trying to spin her web across the

mouth of the cave. Six times she tried, and six times her fragile web was torn down by the wind and rain. On her seventh attempt, she succeeded. Like the spider, Robert the Bruce **had** tried six times before to defeat Edward's army and **had** failed; but the tiny spider surmounted great odds, persevered, and won and in so doing, inspired Robert the Bruce to **make** one last attempt. He emerged from hiding, rallied his troops, and defeated King Edward's army at Bannockburn.

In **many** countries, there are tales of a hero or special individual who escaped his pursuers because a spider **had** built a web across the entrance to his hiding place. David doubted God's wisdom in having created such a useless creature **that** does nothing but spin a web **that has** no value. Yet when he was pursued by Saul and took refuge in a cave, God sent a spider to weave its web across the mouth of the cave. Saul and his men did not enter the cave because they felt that no one could have entered without disturbing the web. Similar tales are told of Mohammed when he fled Mecca to escape from the Coreishites and of Jesus being hidden in a cave to escape Herod's men who searched for him. The lowly, fearsome spider is credited with protecting the lives of the central figures of three major world religions.

### Symbols of Good and Evil

Spiders, within a single culture, can be viewed as good and as evil. In the United Kingdom, there is a common belief **that** it is good luck to see a spider in the house. Though variations on this theme occur regarding when during the **day** or night the spider is seen, the belief that a spider in the house brings good luck is prevalent. Conversely, to kill a spider in the house will bring bad luck. A variation on this is the Money Spider. If a member of this species, a small black spider in England, crosses one's palm, money will soon follow. With this and other species, **many** homeowners will destroy the webs but will carefully lift the spider and put it out of doors. An old English nursery rhyme states:

"If you wish to live and thrive, Let a spider run alive."

The legend of the Christmas Spider, which originated in Germany and the Ukraine, tells the story of how the practice of hanging tinsel on the tree originated. Each year, on Christmas **day**, the Christ child would visit and bless each house. A mother busily cleaned her entire house, even banishing the spiders to the attic. When she was done, and **had** gone to sleep, the tiny spiders crept out of their hiding place and crawled over the entire tree, looking at the beautiful ornaments. In their wake, they left countless draglines of silk. When the Christ child arrived to bless the house, he saw the tree and knew **that** the mother would be dismayed at the sight; so he touched the silk and turned it into sparkling, shimmering, silver and gold. Ever since **that** time, tinsel has been hung on our trees and it is a custom to include a spider among the decorations.

Although spiders have been associated with money, protection, beauty, and even the creation of the **earth** and the transport of the soul to the hereafter, they are still viewed by **many** as cunning, and sneaky, and evil. An extremely large portion of the general population fears them sometimes irrationally. They often represent the unknown evil that lurks in the shadows, waiting patiently to entrap, entwine, and envenomate. In Anglo-Saxon, the word for spider is Attercop, which means, "poison head." Think of it who hasn't walked into the delicate web of a spider in the **dark**, only to backpedal immediately while thrashing and waving their **arms** in fear of being bitten?

### Poetry and Literature

The mention of spiders in the writings of **many** well known authors or writers is common. Shakespeare was not a fan of spiders. In "A Midsummer Night's Dream," he wrote:

Weaving spiders come not here,  
Hence you long legged spinners, hence.

Others include the English writers Spencer and Wyatt. American poet Walt Whitman had a much more accepting and even wondrous view of spiders in his poem "A Noiseless, Patient Spider":

A noiseless, patient spider,

I marked where on a little promontory it stood isolated,  
Mark'd how to explore the vacant vast surrounding,  
I launched forth filament, filament, filament, out of itself,  
Ever unreeling them, ever tirelessly speeding them.

One of the most beloved American poets, Robert Frost, wrote:

I found a dimpled spider, fat and white,  
On a white heal-all, holding up a moth  
Like a white piece of rigid satin cloth,  
Assorted characters of death and blight  
Mixed ready to begin the morning right.

Who among us **has** not heard the Mother Goose nursery rhyme about Little Miss Muffet? **This** standard child-hood rhyme can probably be recited by any over the age of five:

Little Miss Muffet sat on a tuffet  
Eating her curds and whey.  
Along came a spider and sat down beside her  
And frightened Miss Muffet away.

Did you know **that** Miss Muffet was a real person? Her name was Patience Muffet and she was the daughter of Thomas Muffet - a late 16th and early 17th century entomologist. His book "Insectonim Theatrum" contained the first illustration of an insect collected, in North America on Sir Walter Raleigh's second voyage. Muffet **had** a particular penchant for spiders and tolerated and even promoted them in his home. As was common at **that** time, he believed **that** spiders possessed medicinal qualities and **that** consuming them could **cure** a variety of ailments. Consequently, whenever poor Patience was ill, her father would mash spiders and spoon feed her the pulp. No wonder she was afraid of them! Personally, if I were in there home, I wouldn't even sniffle!

Finally regarding spiders in literature, though less eloquent than **Shakespeare** and less insightful than Whitman or Frost Woody Allen summed up the feelings of many when he expressed his fear of spiders in but a single sentence:

"There's a spider in my bathroom the size of a Buick! "

## Art

Spiders **have** been depicted in art far longer than in prose. In fact, the oldest representation of a spider is a drawing on a cave **wall** by a prehistoric artist in Gasulla Gorge, Castellion, Spain - long before any written language existed. It depicts a fat spider and three flies. Over two thousand years ago at Nazca, **Peru**, the Incas etched huge figures of **animals**, birds, and people in the desert sands. Included was a spider over 160 feet across. Interestingly, the full figure can only be seen from the sky.

One of the earliest illustrations of a spider dates from the eleventh century although such illustrations from this period are few. The reason for this is most likely the result of the negative feelings toward spiders as symbols of evil such as the devil weaving his web. Illustrations appear in printed books in the late 15th and early 16th century and it isn't until the early 17th century **that** the illustrations become accurate representations of existing species. One such book is Muffet's "Insectorum Theatrurn (1634). Stilllifes by Brughel and Chellini in the late 17th century show spiders in natural settings.

## Medicinal Benefits

The medicinal benefits of spiders **have** been of interest for well over 1,500 years. The fifth century Roman physician Caelius Aurelianus recommended the **phalangium** spider as a contraceptive. He wrote: "When cut open, there are in it two small worms; they are to be attached before dawn in a piece of deer skin to a woman's body, when they will prevent conception, but only for a year." Pliny the Elder recommended curing "defluxions of the

eyes" by applying the webs **that** line a spider's hole to the forehead as a compress. Incidentally, antidotes for spider bites are not just recently developed **materials**. The ancient Greek Nicader, prescribed antidotes for the bites of phalangia or venomous spider. Such antidotes included rabbit curd, sheep dung, salt and red ochre. Others included immersing the patient in wine, and blood-letting with leeches. Of all the antidotes, I'd personally opt for wine.

The use of spiders to cure a variety of maladies and illnesses was practiced for centuries and lasted into the later part of the 19th century when eating a spider web was prescribed as a cure for the common headache.

With the advent of molecular biology, new and exciting research is showing promise for some of more debilitating medical maladies. Several researchers are investigating spider venom which is a complex mixture of up to a hundred different compounds, each with a different effect. Some of these compounds show promise for victims of stroke, Alzheimer's, and Lou Gerig's disease. For example, it appears **that** venom, if administered to stroke victims within the first few hours of suffering the stroke, can prevent or greatly lessen permanent brain damage. The reason for this is the glutamate blocking ability of the venom. Glutamate in the human brain is responsible for much of the damage **that** follows a stroke.

Spider silk **has** always been viewed as a remarkable material. At least five times as strong as steel, twice as elastic as nylon, waterproof and stretchable, the mass-production of synthetically produced spider silk **has** been a dream **that** until recently was beyond the realm of practicality. Within the past several years, researchers **have** been successful in locating the gene responsible for producing glycine and alanine, the two amino acids **that** are the primary constituents of spider silk. Cornell researchers **have** recently discovered **that** it's the alignment of these two amino acids **that** give the silk it's remarkable strength. Successful insertion of this gene into E. coli bacteria has enabled the limited production of synthetic silk. University, private industry, and even Department of Defense researchers are currently conducting research in this area in the hope **that** genetically engineered spider silk may some day replace materials such as Nylon, Dacron and even Kevlar - the primary component of bulletproof vests.

Additional studies **have** included the use of spiders to determine the effects of various drugs including stimulants and depressants on its ability to produce webs. These **have** included marijuana, benzedrine or speed, caffeine and chloral hydrate, an ingredient of sleeping pills. Spiders on marijuana began spinning their webs but lost interest about halfway through. Those on speed spun their webs with "great gusto" but without much planning and left large holes. Caffeine made them so nervous **that** they could spin little more than a few random lines and chloral hydrate made them "drop off before they even got started."

The great tensile strength of spider silk **has** made it a subject of serious interest to surgical technologists and mechanical engineers including bridge builders.

Continued research with spider venom and silk shows great promise. The rewards of such research may well include relief for stroke victims, the lessening and **perhaps** even the curtailment of the debilitating effects of diseases such as Alzheimer's and Lou Gerig's Disease, and **materials that** may protect and even save the lives of our police and military personnel. This is yet another example of the Jekyll and Hyde view of spiders **that** keeps us so fascinated. They are on the one hand creatures **that** can cause pain, anguish, and suffering yet on the other hand, they show promise of contributing to the quality of life of countless individuals.

#### Food Source

The alleged medicinal value of spider consumption notwithstanding, many people around the world eat spiders. In Southeast Asia, Cambodia and Laos, it's a common sight to see women with roadside stands selling large barbecued spiders on a stick. In parts of China they are favored because of the belief **that** they bring long life. Other peoples of the world **that** relish spiders as part of the regular diet include Indians in South America, the bushmen in Southern Africa and the Aborigines of Australia. Like insect, they provide a rich source of protein.

#### Pest Control

Spiders comprise a large component of both the agricultural and urban ecosystems worldwide. As predators, they consume vast numbers of insects and other arthropods, many of which are pests of crops, forests, urban structures, and man himself. There is ample data to show that spider communities can be effective in regulating pest populations. This is nothing new to the Chinese who for the past few thousand years have placed little straw huts alongside their rice paddies in the fall so that the spiders would have a place to overwinter. Research at the International Rice Research Institute in the Philippines has provided quantification of the important role of spiders as biological control agents in rice fields. The leafhoppers, planthoppers, moths, and caterpillars that attack the rice plants are all attractive food sources for the spiders. Wolf spiders consumed from five to fifteen **small** insects per day while the jumping spiders consumed four to eight green leafhoppers and the lynx spiders averaged two to three moths per day. The night hunters and web builders collected whatever came.

Similar research in the United States, England, and other parts of the world is providing important information into this area of biological control. The Money Spider, of the family Linyphiidae, is an effective predator of aphids in winter wheat in England. By weaving their horizontal webs among the **stalks** of wheat, they effectively net the aphids when they fall. Since they are active earlier in the year than the ladybird beetles, they provide early, critical control.

In general, spiders should be encouraged in crops, orchards, vineyards, plantations, and forests. Spiders cannot be practically mass-produced for release; but those that are naturally available can be encouraged. **It has been** estimated that as much as 99 percent of many pest populations never reach maturity. This is due in part to control by natural enemies; and spiders are very effective biological control agents in many of these environments.

In structures, spiders are excellent natural control agents for a variety of pests. These include cockroaches, fleas, ants, pillbugs, sowbugs, bedbugs, silverfish, a variety of stored product pests, mosquitoes, and even tennites. The brown recluse spider, *Loxosceles reclusa*, for example, is fond of cockroaches. Although one may wonder which population is more tolerable in a structure, spiders rarely bite humans even when living in close proximity. To give a personal example, a sticky trap was placed beneath the sofa in an apartment to monitor a suspected brown recluse spider population. Twenty-four hours later it was removed and **contained** 44 individual spiders - all brown recluse. The inhabitant of the apartment sat on the sofa every night while watching television and had never seen more than a single spider, let alone been bitten by one. Spiders may be used as indicators of pest populations and **their** webs often enable the determination of pest location and population size. Webs can also enable pest identification.

Another interesting use of spiders in the pest control field is insecticide research. Just recently, for example, Australian scientists reported they had determined the molecular structure of a nerve toxin in Australian funnel web spiders and showed it is a **powerful** insecticide with commercial potential with no effects on mammals. The possible consequences of such research are far reaching and may one day lead to a new group of bio-engineered insecticides.

### Aesthetic Beauty

Inherent fear notwithstanding, few of us can look upon the web of an orb-weaver, glistening in the first rays of the morning sun, the dew that clings to each strand exploding into a million tiny diamonds, and not feel wonder. To watch the **female** as she methodically spins her web and attaches each strand in the same fashion over and over all her life, is to observe nature at its finest. Like her namesake, Arachne, she is destined to weave the finest of silk for all eternity.

Who can watch the tiny jumping spider as it pursues its prey, and not feel admiration and wonder for such a magnificent hunter? Though far less swift than the cheetah, no comparison in beauty to the tiger, or as deadly as the great white shark, it is perhaps the most effective hunter on earth. To watch a jumping spider stalk its prey, often losing visual sight with it to gain a better vantage, is to watch beauty in motion. It almost seems that each move is calculated each option weighed. It is difficult not to be anthropomorphic at such times.

### How Do Spiders Fit Into the Realm of Entomology?

There is no discipline of the field of entomology that cannot or should not consider spiders as part of that discipline. From agriculture to urban entomology, from pesticide development to systematics, spiders are as inextricably linked to the field as are insects. Whether it is studying their behavior, their diversity, or their taxonomy, they are linked. Whether field, forest, crop, range or urban dwelling, they are present and very much a part of the ecology. They are part of biological control, part of IPM, part of the medical and veterinary disciplines. The extension entomologist probably receives as many telephone calls and questions about spiders as about any other group of non-insects. They are here to stay. We cannot escape them. They have woven themselves into the very fabric of our field.

*Just* as each of the many disciplines of entomology influence and compliment each other, the many facets of spiders bring them into all areas of the field.

#### Employment Affiliations

Every employment channel available to the entomologist **has** a place for someone specializing in Arachnology. Universities, colleges, state, local and federal government, private **industry**, museums, international and private non-profit organizations all have reason to consider spiders and the varied role they play in our existence. **If** the position does not exist, then make it so. Change, develop, evolve, or create a position. Spiders are here, deal with them; use them, understand them, and share the knowledge of their existence and the role they play on this planet.

#### Conclusions

On August 27, 1883, Krakatau, an island the size of Manhattan located halfway between **Sumatra** and Java, exploded with a volcanic eruption equivalent to a 150 megaton bomb. **What** little remained of the island was covered with as much as 40 meters of pumice and heated to a temperature somewhere between 300' and 8500C. Lead melts at temperatures less than 8500C. The first exploration of Krakatau was conducted nine months later. Only one, single living thing was found. It was a tiny spider, busily spinning its web. It had dropped from the sky after ballooning from some distant shore and was preparing for the next wave of life that would soon arrive.

Spiders have had **nearly** 400 million years to explore the earth and have no intention of quitting. Like their primary food source, the insects, they inhabit nearly every niche. They are patient opportunists. But rather than feeling that we can go nowhere to escape them, we should view it as the opportunity to more fully explore and understand these amazing inhabitants of our world.

Mankind **has** had an arms length fascination with spiders for thousands of years. The paradox of their existence and their ability to often cause us to experience the full range of emotions in rapid succession has made them truly unique in the living realm. They neither apologize for the **fear** they cause nor do they boast at their amazing abilities. They have been nightmare and protector, creator and destroyer, abomination and inspiration. From the amateur to the expert, from the adolescent to the elderly, the study of spiders knows no limits. They **have** much to teach **us**, and we have much to learn.

# IMIDACLOPRID: A CHEMICAL SYNERGIST FOR DISEASE DEVELOPMENT IN TERMITES

Drion G. Boucias  
Department of Entomology and Nematology  
University of Florida Gainesville Florida

*"Two or three termites in a chamber will begin to pick pellets and move them from place to place, but nothing comes o/it, nothing is built. As more join in they seem to reach a critical mass, and the thinking begins. "Lewis Thomas (1974) in The Lives of the Cell*

## Introduction

The soil dwelling **termites** inhabit an environment that is well-suited for colonization by insect mycopathogens. In the subterranean environment the infectious propagules are buffered both from the detrimental fluctuations in humidity and temperature and from exposure to sunlight. Significantly, the microclimate of the **termite** colony is humid, a requisite for the survival and development of insect fungi. Lastly, termites, being social insects, live in high densities and individuals come into contact frequently. Many of the mycopathogens are soil-dwellers and are defined as density-dependent agents requiring high humidity for infection. However in nature, natural epizootics in **termites** is rare; the majority of the reports concerning **termite** diseases are from aging **termite** colonies held in the laboratories. Preliminary bioassays in our laboratory with randomly selected strains of *Beauveria bassiana* demonstrated **that** the **termite** *Reticulotermis flavipes* was resistant to infection by *in vitro*-produced spores. Exposure to high levels of spores did infect a limited number of insects. Amending microcolonies of *R. flavipes* with sporulating termite cadavers stimulated termites to process and remove the cadavers but did not result in any detectable horizontal transmission. These data suggest that this insect possess a high resistance to this mycopathogen.

Insect screening trials conducted by the Bayer reseach group (Vern Beach Labs, Florida) in the early 1990's showed **that** the resistance exhibited by *R. flavipes* against a variety of disease agents is neutralized by exposure to sublethal dosages of imidacloprid. Their multi-year testing effort on this chemical clearly defined its synergistic activity to both pathogenic and opportunistic disease agents. An example of the types of results achieved with this neonicotinic insecticide is presented in Table 1. Naïve **termites** were resistant to an exposure of 108 conidia/g of soil. Amending this assay with a sublethal imidacloprid dosage applied to filter paper discs caused termites exposed of 105 conidia/g of soil to succumb to mycoses. The imidacloprid-termite-mycopathogen interaction **has** provided a valuable model to examine the defense (immune ?) system employed by this social insect against invasive pathogenic organisms.

## The Impact of Imidacloprid on the Internal Defenses of *R. flavipes*

A series of experiments were conducted to determine **if** exposure to low dosages of imidacloprid was immunosuppressive. Groups of **naïve** termites and termites predisposed to imidacloprid received **secondary** challenges of common elicitors of both the cellular and humoral defense systems of **insects** (Fig 1). In the first experiments, termites were **challenged** with FITC-labeled beads to assess the effect of imidacloprid on the phagocytic response. Results of these assays demonstrated **that** the few phagocytic cells present in termites were unaffected by imidacloprid. The second series of assays, involving challenge with the bacterial wall LPS preparations, failed to elicit a response from naïve and test termites. These results suggested **that** *R. flavipes*, unlike other insects, did not possess an LPS-inducible response resulting in the synthesis of antibacterial cationic peptides. Injection of low dosages of live fungal (~1-10 *B. bassiana* cells/termite) or bacterial cells into either treated or naïve insects resulted in rapid mycosis or sepsis. These results, demonstrating that the internal defenses play only a minor protective role, suggested **that** the protection against fungal attack operates at the spore-cuticle interface.

## An Analysis of the Spore-Termite Cuticle Interaction.

The initial **phase** of fungal infection, the attachment of spores to the termite cuticle was examined using FITC-labeled spores. After being surface-treated with the labeled spores, the termites were examined with



epifluorescent optics to determine the number and distribution of attached spores (Fig 2). These experiments, although demonstrating the presence of low and high affinity binding sites on the termite cuticle did not demonstrate any significant differences in the numbers binding to naïve versus imidacloprid-treated termites. However, when these insects were sampled over time, significant differences were observed between the naïve and the treated termites (Table 2). Within hours after treatment, the naïve termites removed more than 75% of the FITC-spores that were detected initially on their cuticle surface. Within 24 hours post-treatment spores were virtually undetected on the rove termites. The fate of the spores attached to imidacloprid-treated termites was drastically different from those on the naïve termites. At 24 hours post-treatment the numbers of spores on the cuticle surface of imidacloprid-treated termites were indistinguishable from those detected at 0 time. Significantly, a portion of the FITC conidiospores detected on the cuticle had a horseshoe appearance, indicating spore germination. The results suggested that the naïve insects were effectively removing the FITC conidiospores from the cuticle surface by grooming. A series of experiments involving naïve termites treated with FITC-conidiospores and dye labeled (fed Nile blue A) termites were incubated together. At various intervals the feces and digestive tracts of the *groomer termites* (untreated blue termites) were removed and examined with epifluorescence optics. Over the entire sampling period (2 weeks) FITC conidiospores were found in the crop of both the groomer and treated termites. No evidence of spore germination was detected in these samples, suggesting that gut microflora possessed a mycostatic activity.

#### Termite Tunnels and Related Microflora: Expression of Mycostatic Activity

In preliminary assays exposure to sublethal dosages of imidacloprid resulted in a dramatic reduction in tunnel construction. Scanning electron microscopy of the termite tunnels revealed that the walls to be were coated with various microbes believed to originate in from the alimentary tract. In light of the observations made with the *groomer termites*, a series of experiments were conducted to assess the effect of the termite microflora on *B. bassiana*. Initial experiments addressed the survival of this mycopathogen in the termite tunnel zones (Fig. 3). In control soils, *B. bassiana* conidiospores germinated and produced progeny spores, whereas in the regions of the termite tunnels rosettes of bacteria were found to encase ungerminated conidiospores. Subsequently, the aerobic bacterial communities from either the tunnel zones or from the alimentary tract of naïve or imidacloprid-treated termites were extracted and assayed for antifungal activities. All of the 100 bacterial communities possessed detectable mycostatic activity. However, individual clones of these bacteria produced only transient mycostatic activity.

#### Social Behavior-The Key Defense Mechanism Against Diseases in Termites

The experiments summarized in the above sections demonstrated that the *R. jlavipes* assayed in groups in the soil environment is resistant to fungal pathogens. This resistance may be overcome by applying massive amounts of spores to the soil. Exposure of termites to low dosages imidacloprid disrupts social behaviors and dramatically increases the susceptibility of termites to pathogenic and opportunistic entomopathogens. Our hypothesis that resistance is due to social behavior is further supported by data generated from assays examining the effect of host density on susceptibility. Whether topically treated or exposed to spore treated soils, the individual termite was highly susceptible to *R. bassiana*. Alternatively, the termites assayed as groups were resistant to infection (Table 3). Increasing the density of the assayed termites resulted in increased levels of grooming and tunnel construction. In summary, termites, being highly social animals, have evolved a potent behavioral defense against soil mycopathogens that is equal to or superior to those defenses operating in nonsocial insects

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Table 1. Effect of *Beauveria bassiana* on naïve versus imidacloprid treated tennites.

Treatment	N	Mean Percent Mortality		
		4 Days	7 Days	14 Days
10 <sup>8</sup> conidialg soil	6	0	1	4
plus imidacloprid	3	7	99	100
10 <sup>7</sup> conidialg soil	3	0	0	0
plus imidacloprid	3	1	80	100
10 <sup>6</sup> conidialG soil	6	0	1	1
plus imidacloprid	5	1	71	100
10 <sup>5</sup> conidialg soil	6	0	0	1
plus imidacloprid	6	0	48	99
Water Control	6	0	0	0
Imidacloprid control	6	1		1

Table 2. Persistence of FITC-labeled conidiospores over time on the cuticle of **naïve** and imidacloprid-treated termites.

Time (hours)	Average Number of Conidiospores Per Field	
	<b>Naïve</b> termites	Imidacloprid Treated Termites
<b>0</b>	21	17
<b>1</b>	15	30
<b>2</b>	5	31
<b>4</b>	3	21
<b>8</b>	2	23
<b>24</b>	<b>0</b>	16

Table 3. Dose response of naive termites exposed as individual or in groups to soil contaminated with varying levels of *Beauveria bassiana* conidiospores.

Treatment	% Mortality at 14 Days	Mean Days to Death
Assayed as Individuals		
Control	2	11
$10^2$ Conidia/g soil	63	10
$10^4$ "	78	9
$10^6$	100	6
$10^7$	100	5
Assayed in Groups		
Control	2	3
$10^2$ conidia/g soil	4	7
$10^4$ "	4	6
$10^6$	5	8
$10^7$	8	7

### Figure Captions

Figure 1. An outline of the various types of experiments conducted to examine the humoral and cellular defenses of both naïve and imidacloprid exposed termites.

Figure 2. The protocol for exposing termites to FITC-labeled conidiospores of *Beauveria bassiana*.

Figure 3. Illustration of the method used to *Beauveria bassiana* conidiospores to the adverse effects of the termites tunneling activities.

## BIOLOGICAL CONTROL BY NATURAL ENEMIES IN INTERIOR PLANTSCAPES AND MODEL ECOSYSTEMS

Mike Rose  
Entomology, Leon Johnson Hall  
Montana State University, Bozeman 59717

Interior plantscapes, and model ecosystems differ from greenhouse operations both in their purposes and scope. In general, interior plantscapes are designed for people, with plantings used for ambiance. Model ecosystems are designed for people, along with a variety of other organisms and a **great** diversity of plants; their purpose is primarily educational. The use of toxic chemicals is inappropriate in such settings. The use of natural enemies, particularly parasites and predators, to regulate pest populations is the **purpose** of biological control. Examples given of effective utilization of natural enemies include *Metaphycus a/berb* for brown soft scale, *Coccus hesperidum*; *Chrysoper/d rofl/abris*, *Anagyrosfusciventris* and *Pseudaphycus ange/icus* for longtailed mealybug, *Pseudococcus /ongispinus*, the two most common and severe pests of interior plantscapes, and *Aphylis h%xanthus* for Florida red scale, *Chrysompha/us aonidum*, the key pest of palms. Further, numerous examples of dispersal by both recently invading and previously established exotic plant pests are given. A plan to take action against this **growing** complex of plant pests is discussed. The actions include implementation of basic tenets of biological control: accurate taxonomic determinations of plant pest species, and the importation, conservation, augmentation and evaluation of appropriate natural enemies; user / advisor / public education and provision of new products (natural enemies) to commercial insectaries.

## EMERGING ARTHROPOD-BORNE DISEASES IN URBAN ENVIRONMENTS

James G. Olson  
Viral and Rickettsial Zoonoses Branch  
Centers for Disease Control and Prevention  
Atlanta, GA 30333

Arthropod-borne diseases include some of the most important diseases caused by parasites, bacteria and viruses. Historically, malaria, typhus, plague, yellow fever and scrub typhus have caused mortality and morbidity that made them scourges of mankind. Great progress in the control of vector-borne diseases has been made in the 20th century. The implementation of vector control strategies based on the use of DDT were directly responsible for nearly eradicating malaria from the Americas and Asia, for elimination of urban plague and for the simultaneous reductions of urban yellow fever and dengue fever. By the early 1970s arthropod-borne diseases were no longer considered to be of major public health importance. In contrast to the early and dramatic successes, we are now faced with dramatic reemergence of vector borne diseases previously controlled. Malaria causes 300-500 million cases resulting in 1.5 -2.5 million deaths annually. Nearly 100 million cases of dengue fever occur annually. With the reinvasion of tropical urban centers by *Aedes aegypti*, the risk of urban yellow fever outbreaks is increasing geometrically. The question is no longer if they will occur, but when and where. Although many of the factors that have been responsible for the global resurgence of vector-borne diseases are poorly understood, several obvious associations can be documented. The population of the earth is rapidly becoming urbanized. The growth of the large macro cities of the tropics will continue and the migration of rural populations into those cities largely for economic gain will serve to maximize the probability of introductions of diseases restricted to sparsely populated rural areas into urban settings. The international emergency in financial support for a decaying public health infrastructure has undoubtedly contributed to the problem. Periodic explosive outbreaks of Japanese encephalitis, West Nile fever, Rift Valley fever, Oropouche fever, Ross River fever and Chikungunya fever may occur.

Arthropod-borne diseases will continue to be a threat to the urban and suburban populations of the United States. The risk of catastrophic morbidity and mortality is several orders of magnitude lower than in the tropics. However, several new diseases have emerged in the last few decades. Lyme disease, granulocytic ehrlichiosis, monocytic ehrlichiosis, Powassan encephalitis, and cat flea typhus. Others, including St Louis encephalitis, flea-borne typhus, rickettsialpox and perhaps eastern equine encephalitis and western equine encephalomyelitis are increasing or threaten to increase in importance.

## ETHICAL CONSIDERATION IN EXTENSION, RESEARCH & INDUSTRY PROGRAMS

Roger E. Gold  
Center For Urban & Structural Entomology  
Department Of Entomology  
Texas A&M University  
College Station, TX 77843-2475

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FORWARD: I **have** taken on the challenges associated with the preparation of this presentation with some fear and trepidation. First, because I in no way am putting myself forward as a model for ethical **behavior**, although I do understand the concepts of ethical **behavior** and attempt to practice them. Secondly, even though I attended institutions of higher learning, courses in ethics were not part of the primary curriculum, and so while I had several introductions to this topic in courses in philosophy, sociology, physiology and the history of science, I never had a course directly specifically at the languages of ethics. In preparation of this presentation, I read three texts (indicated in references) which in addition to challenging my thought processes and endurance, did provide some insights in this subject. I also interviewed a lawyer, a clergy person, and a philosopher about their suggestions on subject matter to be covered in the presentation. Perhaps the most significant contributions **came** through discussions with Drs. **Harry** N. Howell, Jr. and Mark Wright, of my staff, who are among the most ethical people with whom I have ever worked, and have taken me to the edge on ethical discussions. In addition, we at Texas A&M **have** received a mandatory training titled, "Keeping Faith With Texas: A Course On Ethical Policy And Laws For Employees Of The Texas A&M System". This type of training is now more the rule rather than the exception in academics as well as industry, which I consider to be a positive approach to teaching some of the more basic ethical theories.

ABSTRACT: Ethics are the standards of conduct **that** indicate how people should **behave** and are based on principles of right and wrong. Ethical principles are the rules derived for ethical values. Some examples of ethical values are: trustworthiness, civic virtue, citizenship, responsibility, caring, respect, justice and fairness. Therefore ethics is concerned only with **that** portion of human behavior susceptible to the descriptive of "right" and "wrong". The behavior of animals, infants and insane entomologists (mentally ill) are not considered either ethical or unethical because there is no attribution of right or wrong. Further distinctions are **made** between terms such as morals, laws and customs (etiquette). Laws and morals are somewhat similar in **that** they deal with interpersonal relations and actions, which affect others. Laws are **made** and enforced by **individuals** or groups or **individuals** while moral rules and etiquette seem to have evolved with society. Further distinctions made between anthropology, sociology, psychology and ethics. These studies examine how people behave, while ethics is how "they ought to behave". The difference therefore is a distinction between "is" and "ought". Nonnative ethics is the study of the norms or criteria by which we judge actions of "right" and "wrong". Meta-ethics is the study of ethical discourse. There are specific criteria for assaying nonnative theory including 1. Consistency (theories and expectations do not differ), 2. Universalism (what is right for one is right for all), 3. Relative completeness (when comparing theories for ethical behavior, more weight is given to complete theories), and 4. Parsimony (the simpler theory will be favored over complicated approaches).

Some of the more widely discussed **normative** ethical theories are 1. Situation Ethics (no set rules because each situation is considered unique), 2. Fonnalism (Species standards used to evaluate moral qualities of action including; fidelity, reparation for injury, demonstration of gratitude, happiness and pleasure distributed by merit, improving conditions of others, obligation for self-improvement and obligations not to harm others {based on



"Golden Rule"}), 3. Act-Utilitarianism (act evaluated by consequences on other-produce greatest balance of good over evil), 4. Rule-Utilitarianism (act not evaluated, but classes of actions evaluated), 5. Agape (basic tenet is to "love" {Matt: 22:37-39}), and 6. Divine wills (Supreme Being reveals to prophets or others what is right or wrong).

Meta-ethics involves some of the following discussion: 1. Emotivism (logical positivism where statements must be logical and analytical), 2. Naturalism (ethical statements are fact-stating assertions based on the "nature of man"), 3. Intuitionism (basic moral principles are self-evident and based on "rational insight"), 4. Noncognitivism (no inductive or deductive proof can be used to set "correctness" of action or rule), and 5. Axiom theory (normative principles based on a set of scientific axioms).

While there is no universal acceptance of which of the ethical theories is correct or appropriate for any given situation., there are some themes that I understood and that appear to have merit to urban entomologist. In making this statement, I recognize and admit to **certain** prejudice based on the way I was raised in a Judeo-Christian family. It appears that most of the principles can be met with the simplest approach of "doing no **harm** to others", and "treating others as we would like to be treated". I would also add to the ethical receipt certain values such as trustworthiness, virtue, truthfulness, fidelity, respect and justice. With this explanation., I would offer the following Ethical Case Studies in Urban Entomology, which can be discussed in open session or merely considered as individuals:

1. Confidentiality
2. Recommendations (specific products or generics)
3. Purchased influence (grants, awards and gifts)
4. Protection of the public interest
5. Conflicts of interests
6. Unbiased data collection (use of scientific methods)
7. Unbiased data analysis (data manipulation/normalization)
8. Recognize the work of others (academic honesty at all levels)
9. Eminent danger (protect interest of least or most susceptible humans)
10. Need for efficacy data prior to sales or recommendations
11. Employer loyalty (at all cost)
12. Personal attacks based on research outcomes (justified/unjust)

CONCLUSIONS: While I has not been my intent to either teach a course in ethics (not that I could), or to point a finger at those that may have less than ethic standards of ethical behavior, but that we as colleagues need to understand that we all are expected to be ethical regardless of our professional employment, our background. We all have room for improvement, including myself, and the preparation of this presentation has focused me on areas that I must explore. I would invite each person reading this presentation or participating in the discussion that follow, to conduct a self examination and see where we can become more ethical in our conduct.

# EFFECTIVE QUALITY CONTROL FOR PEST CONTROL COMPANIES

Jim Wright  
Department of Entomology, Clemson University  
Clemson, SC

## Introduction

Experience has shown that many companies develop standards and policies designed to ensure quality work and compliance with regulatory requirements. However, often, employees fail to comply with the established company policies resulting in call backs, damage claims and regulatory concerns. An effective quality control program will help companies ensure compliance with these policies and standards. To date, most quality control efforts have been one dimensional in that the company employs one thing for ensuring adherence to company policy. **As** we will discuss, successful quality control is made up of several elements that operate in sync to ensure quality work. In fact, we talk of the QC program as an aggregate of activities that, by design, confirm adequate quality.

## History of Quality Control

Quality Control is not necessarily a new idea for industries in the United States. Experts have, for decades, known and understood the benefits of successful quality control in manufacturing industries. Quality Control (QC) is defined by Webster as an aggregate of activities designed to ensure adequate quality. As you will see, the important thing to understand is that there is not one element to quality control which will insure that the final product of any industry will automatically meet a quality standard. Any discussion of the history of QC must include the names of Edward Deming, Joseph **Juran**, and AN. Feigenbaum.

A quick look at Japanese manufacturing is a perfect example of how the process of QC can affect the overall success of industries. There is no comparison to the Japanese products today and those of the post war era of the 1950s. By the 1970s the Japanese had begun to present a completely different image to the world regarding the quality of the products manufactured in their country. This was largely due to the initial work done with the Japanese by Edward Deming during the 1950s in statistical quality control. However, as the Japanese began to implement these practices, they ultimately established the foundation for the QC efforts in their country today.

Another important person responsible for the success of Japanese quality control is Joseph **Juran**. He followed **many** ideas of Deming in that he advocated the implementation of a statistical quality control effort. It appears that Japanese management officials saw the wisdom in Juran's ideas and many of them began to integrate these ideas into the management of their companies.

Finally, the Japanese carried this a step further when they incorporated the ideas of Feigenbaum into the existing QC practices. Feigenbaum originated a process for QC that hinges on the concept of an integrated approach to QC that has its common denominator woven through all parts of production. Feigenbaum advocated the idea of a fully integrated process that insured quality through the entire production effort from the raw materials up to and including customer satisfaction. Because of this transition away from prior conventional thinking in the industrial arena, the Japanese surpassed the United States and other countries in the production of many things to include automobiles and electronics.

If you combine the thoughts of Deming, Juran and Feigenbaum on what, QC actually means the picture would largely parallel the definition provided by Webster. That picture suggests that you would:

- Establish acceptable standards
- Document and analyze the performance of your employees
- Correct the deficiencies
- Determine how to provide a better service to your customers

As you can readily see, there is not one simple thing to do to accomplish QC. Rather, it is the integration of many things at once to see that your standards are met, corrected **if** necessary and insuring that changes are made.

It has been stated that the service industries need to embrace the notions of QC much like the manufacturing industries. The most glaring problem with QC as it relates to most service industries is that they do not have clear or definitive guidelines for providing or evaluating the particular service. The pest control industry is no different from any other service industry in that the problems with QC clearly reside throughout the **industry**. There are little or no references to the successes of QC in pest control companies. The references that do exist either are anecdotal or lack sufficient detail to give the PCO adequate guidance to **carry** out a successful long term QC program. While some **standards** do exist, many pest control companies have not availed themselves of the opportunity to move in the direction of long term QC. It is true **that** in past decades the industry may have lacked clear guidance regarding how best to evaluate the work they perform. However, those times are very quickly disappearing.

Does every company need QC? Absolutely! Pest control companies can no longer afford to discount the need to insure the quality of their work. The most obvious indicator that quality control is a problem lies in the increased efforts from the regulatory community and the increase in the number and **type** of litigations facing pest control companies.

A compounding problem for all pest control companies **today** is the fact **that** they can no longer rely on the efficacy of some products. Environmental sensitivities will no longer give us the luxury of a persistent and forgiving pesticide product. The products **today** must be applied in a nearly perfect way to get the necessary efficacious response. The pest control operator has to be aware of many concerns of his customers. Pest control companies must be constantly aware of the perceptions of their customers. One way to make certain **that** your customers have the correct perception of your company is to **carry** out a QC program **that** will help your company be consistent in the way you do business.

All people responsible for QC in your company have to have a complete working knowledge of the entire quality objective. Remember, we established **that** quality control is not just one thing. It is a combination of several things that are necessary to see **that** the product (service) is of adequate quality. The QC effort should be the responsibility of every employee. As a manager, you have the responsibility to express to the employees effectively the expectations you hold for them in everything they do. This is also true of your QC efforts. True QC begins with the employees understanding and meeting the expectations established by the company.

### Who Should Do Quality Control in Your Company?

The responsibility for insuring the QC effort is met is one **that** should be separated from the production side of the business. Historically, we have seen pest control companies attempt to make certain the services are done correctly by using employees who are *also* responsible for providing the services. Total or complete QC is not an effort **that** will generate cash flow in the short term. Many managers will focus on the immediate benefits of increasing the flow of capital into the business without insuring the quality of the service meets prescribed expectations. Inevitably the manager must decide whether to perform QC or generate cash flow. This is especially difficult **if** the people responsible for QC of the treatments **are** tied to the production side of the business.

QC is a problem with all companies of all sizes. Cash flow is a concern for all companies of all sizes. **If** you integrate the two, the result is destined to be disaster. Employees who **are** providers of the services your company performs should be part of the QC effort. However, these people should not be solely responsible for the success of your QC program. What **may** be the most difficult part of the commitment to a viable QC program is the dedication of employees who are responsible for ensuring that other employees meet the standards set by the company. Attempts have been **made** in the past to allow employees to check behind themselves to see that the work is done correctly. **Human** nature dictates that **if** we are working and we know that no one will ever check the work, we are likely to fail to properly do the work eventually.

We have seen companies in the past who **started** a quality control or quality assurance program. A close look at these programs revealed, the salesperson or another production employee would telephone the customer and ask whether they were satisfied with the work or not. This places the entire success of the QC effort on the working knowledge of the customer. Past attempts have been **made** to hold the salesperson responsible for the QC. The idea is to couple the payment of a commission to the quality control process directly. This amounts to the same as

requiring a production employee to do the inspection. Eventually, the salesperson will fail to report the problem for fear that the commission will be withheld until the problem is corrected. Thus, the production issue comes back into the picture. Remember, complete QC *is* a collection of many things that make *it* successful when integrated together. Thus, the real success of the quality control program lies in the post treatment inspection by the people responsible for QC in your business.

The best way to see that your company's QC program is successful is to have the people responsible for the actual QC inspection answer only to the owner\manager of the company. This removes these employees from the production effort of the business. Further, **this** will most likely help the successful development of a long term effective QC program.

## The Elements of a QC Program

### A) Establishing Acceptable Standards

The first element of any complete QC program is to establish standards for your company. Without setting these standards there is nothing to use as the benchmark necessary to measure the work done by your employees. These standards must be realistic and based upon what the company feels is the best way to perform the service. Every element of the total QC program is predicated on the establishment and compliance with these standards.

A possible source of a standard is the *Approved Reference Procedures* established by the NPCA. These standards are universally accepted as having a scientific yet pragmatic foundation. These procedures have a long-standing acceptance by pest control companies and are easily understood by employees. Another source of a standard could be treatment standards established by your particular state regulatory agency. The regulators are going to expect you to comply with the respective legal requirements in your state no matter the standard you set and this **may** help eliminate any confusion resulting from the use of a different standard. Professional industry consultants can give you a broader base from which to establish a standard. These individuals can probably share with you the very best of several possible solutions to help your company be successful. Finally, the pesticide labels are an excellent source for how to apply products. Most manufacturers are interested in seeing the efficacious use of their pesticide product.

### B) Documentation and Analysis of Performance

After you have set the standards which establish the expectations for your employees, you now have the task of measuring performance. The standards are meaningless unless you effectively check for compliance with them. As stated earlier, **if** no one monitors the employee, their work will eventually fall below the level of expectation. **If** they feel that they do not have to comply with a standard because their work will never be evaluated, the standard is useless.

We know the best person to accomplish the task of making the evaluation regarding the compliance with company policy or standard *is* a person who is not tied to the production side of the business. The best method of accomplishing this is to conduct an on site inspection of the work. An employee then **has** an understanding that his or her work will be evaluated by the QC inspector and any problems must be corrected.

The measurement of performance and the analysis of the performance must be well documented by your quality control personnel. This documentation is extremely important when you are deciding how to improve the performance of your employees. An example of how to document the performance of your company is seen in the attached Quality Control Inspection Form. The form prompts the inspector to respond to many things about the structure, the treatment of the structure, and the QC inspection. This form gives you the opportunity to evaluate the actual performance of your employees. It supplies you with a database of information that can easily reveal a problem with an employee or with the training program for all employees. You can easily isolate the top omissions discovered during your QC inspections thus giving you the opportunity to correct discrepancies before they become problems. The use of complete and detailed documentation is the cohesive element of any QC program. Without the documentation you have no mechanism to measure success. This documentation should also prove

valuable **if** a potential problem were to arise with this account at some point in the future. This could serve to prove that you attempted to do all that you could to see that the treatment was done correctly.

The continued success of the quality control program is dependent on the analysis of the performance. **If** you are going to assume that just because you set the standards and inspect them that it is enough, your program is destined to fail over time. Your QC inspector with the **owner/manager** must do a critical **analysis** of the results of the post treatment inspections. This is the basis for the feedback to the rest of the company regarding **what** is necessary to enhance the compliance of the company standards. Better compliance with these established standards eventually **means** fewer potential problems with these treatments and eventually results in your business being more profitable.

### C) Correcting Any Deficiencies

Based upon the results of the post treatment inspection and the measurement of your performance, you **have** an obligation to make all corrective measures. This gives your company a unique opportunity. You can instill a very high level of confidence in your customers by demonstrating to them that not only can you do what you promised by doing the work you can prove to them that you are following up on that effort. Your company appears very professional to the average customer when they see another of your employees do a post treatment **inspection**, especially, **if** your QC inspector effectively communicates to that customer that they are insuring the completeness of the work. Anyone can see **that** this is much different from telephoning the customer and asking them **if** they are satisfied with the work performed.

it should be written company policy to correct any substandard treatments within a prescribed amount of time. The corrections should be accomplished after a supervisor has the opportunity to discuss the problem with the employee detailing verbally or in writing the problems with the employee's work. A very effective tool is to make this feedback process progressive. This gives the employee the chance to understand the requirements and make changes in their work **habits**. **If** the changes are not made by the employee, the company must have a plan that will ensure compliance.

As a **manager/owner** you have to be prepared to take the necessary, disciplinary action to make certain your expectations are met. You should **have** a clear written policy for the employees that details the responses from the company **if** the standards are not consistently met. You also must make certain **that** the employees understand the consequences for their actions and be prepared to follow through with the disciplinary action necessary to protect the interest of the company. Finally, to make a QC program successful you must properly document the problems and be prepared to correct the problems by properly training the employee, retraining when necessary and taking the appropriate disciplinary action when you **have** no other alternative.

### D) How to Provide Better Service to Your **Customers**

Every company needs to **have** someone who is responsible for training new employees. This **has** many obvious benefits like **having** the employees consistently interpreting the standards set by the company. It also provides a mechanism for gathering the feedback from the post treatment inspection documentation and making decisions about specific problem areas that need to be addressed in more detail. **If** you consistently see similar or persistent problems among several employees, it may not be a discipline problem it may be a training problem.

You should also be prepared to take an employee and put them through some element of retraining. This is an important concept. How often have you hired an employee that came to you from another company and seen immediately things that you liked and things that you did not like about their work? Understanding **that** there is a tremendous investment in the training of new employees is important. The pest control industry estimates **that** it cost an average of \$10,000 to train an employee properly. Be prepared to do an effective evaluation of the employee's work and make any necessary adjustments to their level of expertise and keep them on the payroll. This is always less costly to the business **than** training a new employee who may have just as many bad habits as the old employee. This will also tend to slow the attrition rate industry wide which, over time, will make your employees more knowledgeable and your business more profitable.

It is extremely important to plan to provide good service to your customers. Good service has to have a common thread woven through every aspect of your business. It has to be present in the attitude of every employee. The commitment to good service has to be seen in the QC program in each company. As we have seen, good quality control is the net effect of establishing standards for your company, documenting and analyzing the **performance** of your employees and correcting the deficiencies in the service you provide. Effective QC can help your company enjoy the success of providing quality service to your customers for **many** years to come.

## **Reference**

Ogg, Neil L., (1992). The Relationship of Selected Variables on Pest Control Operators' Compliance With Subterranean Termite Treatment Standards. (Doctoral Dissertation, Clemson University, Clemson, S.c.).

**AN ANECDOTAL HISTORY OF THE FORMOSAN SUBTERRANEAN  
IN HAWAII**

Minoru Tamashiro  
Department of Entomology  
University of Hawaii  
Honolulu, HI

Abstract not available... ..

SEASONAL AND SPATIAL CHANGES IN FORAGING ACTIVITY OF *RETICULITERMES* SPP.  
(ISOPTERA: RHINOTERMITIDAE) IN A NATURAL LANDSCAPE

Richard M. Houseman and Roger E. Gold  
Department of Entomology  
Texas A&M University  
College Station, TX 77843-2475

REFERENCE: Houseman, R. M. and R. E. Gold. 1998. Seasonal and spatial changes in foraging activity of *Reticulitermes* spp. (Isoptera: Rhinotermitidae) in a natural landscape. Proceedings of the National Conference on Urban Entomology, 1998.

ABSTRACT: Understanding seasonal shifts and spatial rearrangements of subterranean termite foraging activity may be important in developing effective strategies for installing and evaluating commercial baiting systems. We investigated changes in the spatial dispersion of *Reticulitermes* spp. in a natural **habitat** throughout one yearly cycle. Hollow, wooden monitoring stations were installed at 2.5m intervals in a 12 station x 12 station square grid pattern. At biweekly intervals all monitoring stations were checked for the presence of subterranean tennites. The estimated number of individuals in an occupied station was used as an indicator of station activity. Soldiers were collected for species identification. Observations were made to **examine** seasonal changes in the activity, number, and spatial arrangement of monitoring **stations** occupied by subterranean termites. Lacunarity analysis was used to quantify spatial dispersion within the grid and Mantel's z-statistic identified significant rearrangement in spatial patterns between successive sampling dates.

The average number of *Reticulitermes* spp. individuals within occupied stations was highest during the spring and fall and lowest during the summer. *Reticulitermes* spp. foragers located 32 monitoring stations throughout the year. Initially, the number of occupied stations equaled the number of located **stations**, but eventually the number of occupied stations began to fluctuate at levels below the number of located stations. The number of occupied stations was highest during the spring and fall and lowest during the winter. The mean number of occupied monitoring stations throughout the year was  $16.2 \pm 4.7$ .

Two subterranean tennite species, *Reticulitermes flavipes* (Kollar) and *Reticulitermes hageni* Banks, were identified from collections within the grid. Seasonal **changes** in the average activity and in the number of occupied monitoring stations were different for each species. *Reticulitermes flavipes* was more active during spring, fall, and winter, and occupied a greater number of monitoring stations during spring and winter. *Reticulitermes hageni* was more active during summer, and occupied a greater number of monitoring stations during summer and fall.

Lacunarity analysis of the spatial distribution of occupied monitoring stations reveals **that** *Reticulitermes* spp. activity is clustered during fall and winter and scattered during spring and summer. Changes in spatial dispersion from successive biweekly sample dates were not significant according to Mantel's z-statistic, so significant change in spatial dispersion was analyzed at monthly intervals. Significant spatial rearrangements of occupied monitoring **stations** were identified in the intervals from June to July, September to October, December to **January**, and January to February.

Significant spatial rearrangement in the dispersion of subterranean tennites within the grid may coincide with oscillations in the relative activity of *R. flavipes* and *R. hageni* within occupied monitoring stations. A significant change in spatial dispersion occurred from June to July when the average activity of *R. hageni* surpassed **that** of *R. flavipes*. Another significant spatial change was observed from September to October when the activity levels of *R. flavipes* surpassed *R. hageni*. Significant spatial rearrangements from December to January coincide with marked increases in activity levels of both species and a significant spatial rearrangement from January to February occurred when activity levels of *R. hageni* increased while levels of *R. flavipes* were decreasing. Similar relationships are observed between relative numbers of active monitoring stations occupied by each species and intervals of significant spatial rearrangement.

Foraging patterns of subterranean termites in a natural landscape indicate **that** activity fluctuates seasonally in terms of the number and spatial arrangement of foraging locations. Spatial rearrangement in the locations of



foraging termites may coincide with shifts in the relative activity of individual species. These factors should be considered in the design and evaluation of subterranean termite baiting systems.

**KEYWORDS:** *Reticulitermes*, subterranean termites, foraging, spatial dispersion, **lacunarity**, Mantel statistic, baits

TEMPERATURE EFFECTS ON CASTE DIFFERENTIATION AND SECONDARY COLONY  
FORMATION OF ~~THREE~~ SUBTERRANEAN TERMITES IN THE GENUS *RETICULITERMES*  
(ISOPTERA: RHINOTERMITIDAE)

Thomas E. Macom, Barry M. Pawson and Roger E. Gold  
Department of Entomology  
Texas A&M University  
College Station, TX 77843-2475

Reference: Macom, T. E., B. M. Pawson and R. E. Gold. 1998. Temperature Effects on Caste Differentiation and Secondary Colony Formation of Three Subterranean Termites in the Genus *Reticulitermes* (Isoptera:Rhinotermitidae). Proceedings of the National Conference on Urban Entomology, 1998.

Abstract: Termites are hemimetabolous insects, whose colonies are made up primarily of immature individuals who retain the ability to differentiate under **specific** conditions. Conditions like loss of soldiers, loss of queens, and development of alates for mating flights can initiate caste differentiation by pseudergates (workers), nymphs and larvae to develop into these caste. The plasticity of caste differentiation in termites is complex and important in regard to urban pest **management** because it allows the survival of groups of individuals who have lost or have been separated from their reproductive caste to develop new reproductives and continue to propagate. We investigated the effects of temperature on caste differentiation and secondary colony formation in three species within the genus *Reticulitermes* (*R. flavipes*, *R. virginicus*, and *R. hageni*). Nineteen colonies in and around Bryan/College Station, TX were collected and identified using alates collected in the spring before or after the initiation of the experiment. Eleven of the colonies were *R. flavipes*, five of the colonies were *R. virginicus* and three of the colonies were *R. hageni*. The colonies were collected in bucket/block traps at the end of July 1997. The colonies were brought into the laboratory, separated from the block and the caste proportions counted. Four groups of 200 pseudergates were separated from each colony and placed into a petri dish 100 mm in diameter by 15 mm with filter paper and a moistened birch tongue depressor ~ 5 cm in length. One group from each colony was placed into one of four temperatures 15, 20, 25 and 30°C and observed weekly for the presence of different caste and the production of eggs. Colonies were removed from the experiment when the fragmented groups developed into secondary colonies. Experiment is currently ongoing. Descriptive statistics were mainly used and when appropriate T-test and one-way ANOVA were used to test differences between temperatures and between the different caste.

All colonies **decreased** in size on an average of 40% mortality for the colonies held at 25°C with a high of 60% and a low of 20%, an average of 48% mortality was observed for colonies held at 30°C with a high of 65% and a low of 25%. Colonies at 15 and 20°C have not developed into secondary colonies, subsequently counts have not been made. Caste differentiation **occurred** in all three species and at the four test temperatures. During the experiment only one second-form or neotenic developed while 58 third form or ergatoid reproductives formed.

Eggs were laid at 25 and 30°C for all the species observed, eggs were laid at 20°C for *R. flavipes*, but they did not hatch for reasons unknown. At 20°C the first egg clutch appeared at the 30 wk and only occurred in *R. flavipes*, at 25°C the avg. time to the first egg clutch for *R. hageni*, *R. virginicus* and *R. flavipes* was 17 wk, 22 wk and 14wk respectively, at 30°C the avg. time to the first egg clutch was 9.5 wk, 24 wk and 15 wk for *R. hageni*, *R. virginicus* and *R. flavipes*, respectively. No eggs were laid up to this point at 15°C. Soldiers and nymphs occurred with in the first 5wk for *R. virginicus* and *R. flavipes* at all of the temperatures tested. This is probably a result of the time of year the colonies were collected. *R. hageni* was very sensitive to low temperatures and soldiers have yet to appear after 38 wk at 15°C, nymphs appeared at the 28 wk. Soldiers appeared at 7, 6 and 2 wk at 20, 25 and 30°C, while the first brachypterous nymphs appeared at the 28, 9, 4, 3 wk at 15, 20, 25 and 30°C. Supplemental reproductives have not appeared yet for *R. hageni* and *R. virginicus* at 15 and 20°C. Supplemental reproductives appeared at 24 and 7 wk for *R. flavipes* at 15 and 20°C respectively. Supplemental reproductive **appeared** at 25°C at 7, 21 and 8 wk for *R. hageni*, *R. virginicus* and *R. flavipes* respectively, while at 30°C they appeared at 5, 23 and 10 wk respectively. This indicates *R. hageni* does better at higher temperatures than *R. virginicus* and *R. flavipes*.

Secondary colonies appeared for all the at the 25 and 30°C temperatures. *Reticulitermes hageni* was the first to develop secondary colonies at 30°C (10 wk), while *R. flavipes* was the first to develop a secondary colony at 25°C (12 wk). *Reticulitermes virginicus* took the longest to develop into secondary colonies at both temperatures 20 wk

and 26 wk at 25 and 30°C respectively, while *R. hageni* took 16 wk and 10 wk and *R. flavipes* took 12 and 14 wk respectively.

Total caste production was highest at 30°C and decreased as temperature decreased. Average caste production for *R. hageni* was lowest at 15 and 20°C and greatest at 25°C and 30°C with an avg. of 0, 0.33, 3.3 and 4.3 soldiers, 0.75, 0.33, 1.3 and 3.6 nymphs and 0, 0, 3.4 and 3 supplemental reproductives respectively. Average caste production for *R. virginicus* was lowest at 15 and 20°C and greatest at 25°C and 30°C with an avg. of 0.33, 0.75, 2.6 and 2.7 soldiers, 0.4, 0.6, 0 and 0.6 nymphs and 0, 0, 0.4 and 0.6 supplemental reproductives respectively. Average caste production for *R. flavipes* was lowest at 15 and 20°C and greatest at 25°C and 30°C with an avg. of 0.2, 0.3, 2.3 and 3.2 soldiers, 0.9, 0.8, 1.4 and 1.4 nymphs and 0.2, 0.4, 1.9 and 1.3 supplemental reproductives respectively.

Temperature greatly effected the rate of caste differentiation and secondary caste formation between and among the species tested. Cooler temperatures reduced the avg. number of individuals and total number of individuals that differentiated within each group of individuals. More reproductives were produced at 25°C than 30°C and very few were produced at 15 and 20°C indicating possibility of seasonal and microhabitat control of egg laying.

**Keywords:** Temperature, Subterranean termites, Reticulitennes, caste, differentiation.

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## SEASONAL FORAGING BEHAVIOR OF *RETICULITERMES* SPP. IN NORTHERN CALIFORNIA

Gail M. Getty<sup>1</sup>, Michael I. Haverty, Kirsten A. Capren<sup>1,2</sup>, and Vernard R. Lewis<sup>3</sup>

[Chemical Ecology of Forest Insects, Pacific Southwest Research Station, USDA Forest Service, P.O. Box 245, Berkeley, CA 94701

<sup>2</sup> Department of Entomology & Center for Population Biology, University of California, Davis, CA 95616

<sup>3</sup> Division of Insect Biology, Department of Environmental Science, Policy, and Management, University of California, Berkeley, CA 94720

REFERENCE: Getty, G.M., M.I. Haverty, K.A. Copren, and V.R. Lewis. 1998. Seasonal foraging behavior of *Reticulitermes* spp. in northern California. Proceedings of the National Conference on Urban Entomology, 1998.

ABSTRACT: Foraging and wood consumption by *Reticulitermes* was examined in one wildland and one residential site in northern California. The wildland site was an arboretum composed of *Pinus* species in the high foothills of the Sierra Nevada near Placerville, CA. The residential site was a coastal valley near Novato, CA. Three hydrocarbon phenotypes of *Reticulitermes* were found at the wildland site and two hydrocarbon phenotypes at the residential site. The number of termites foraging at monitoring stations in the wildland site appeared to be seasonally variable. Termite numbers were low in the winter and high in the summer. However, high summertime temperatures appeared to depress termite numbers. The seasonal cycle of termites foraging in monitoring stations was not clearly defined in the residential site. Wood consumption in monitoring stations displayed a definite seasonal cycle, for both wildland and residential sites, and may be a better indicator of termite activity. Wood consumption was minimal in winter, increasing in spring, peaking in late summer and early fall, and declining in late fall. All cuticular hydrocarbon phenotypes displayed similar seasonal trends in wood consumption.

KEYWORDS: subterranean termites, foraging, feeding behavior, wood consumption

# SIZE AND DISTRIBUTION OF *RETICULITERMES* COLONIES IN A WILDLAND AND RESIDENTIAL LOCATION IN NORTHERN CALIFORNIA

Michael I. Haverty<sup>1</sup>, Gail M. Getty<sup>1</sup>, Vemard R. Lewis<sup>3</sup>, and Kirsten A. Copren<sup>1,3</sup>

<sup>1</sup> Chemical Ecology of Forest Insects, Pacific Southwest Research Station, USDA Forest Service, P.O. Box 245, Berkeley, CA 94701

<sup>2</sup> Division of Insect Biology, Department of Environmental Science, Policy, and Management, University of California, Berkeley, CA 94720

<sup>3</sup> Department of Entomology & Center for Population Biology, University of California, Davis, CA 95616

REFERENCE: M.L. Haverty, G.M. Getty, Y.R. Lewis, and K.A. Copren. 1998. Size and distribution of *Reticulitermes* colonies in a wildland and residential location in northern California. Proceedings of the National Conference on Urban Entomology, 1998.

ABSTRACT: Foraging populations and distribution of colonies of *Reticulitermes* were determined at one wildland and one residential site in northern California. The wildland site was an arboretum composed of Pinus species in the high foothills of the Sierra Nevada near Placerville, CA. The residential site was a coastal valley near Novato, CA. Three hydrocarbon phenotypes of *Reticulitermes* were found at the wildland site and two hydrocarbon phenotypes at the residential site. All sites have numerous, relatively small colonies coexisting in the same area. The number of foraging termites in a colony were estimated by both the Lincoln Index and the weighted mean model, and ranged from ca. 4,500 to 500,000 foragers. Estimates of foraging populations by these two methods differed by as much as 3X for the same colonies. We favor categorizing colonies into groups, i.e. small, medium, large, or extra large, rather than considering the estimates to be precise. Territories utilized by colonies are relatively small and comprised of as few as one monitoring station up to nine monitoring stations no more than 25m apart. Foraging territories can overlap, are not static, expand and contract, and can be sequentially occupied by different hydrocarbon phenotypes.

KEYWORDS: subterranean termites, foraging populations, foraging territory, mark-release-recapture, Lincoln Index

# MARK-RECAPTURE WITH THE FORMOSAN SUBTERRANEAN TERMITE TO STUDY THE MOVEMENT OF FORAGERS AMONG FEEDING SITES

Nan-Yao Sui, and Michael I. Haverty<sup>2</sup>

Ft. Lauderdale Research and Education Center, University of Florida, 3205 College Ave., Ft. Lauderdale, FL  
33314

<sup>2</sup> Pacific Southwest Research Station, USDA Forest Service, P.O. Box 245, Berkeley, CA 94701

REFERENCE: Su, N.-Y., and M. I. Haverty. 1998. Mark-recapture with the Formosan subterranean termite to study the movement of foragers among feeding sites. Proceedings of the National Conference on Urban Entomology, 1998.

ABSTRACT: Mark-recapture techniques have been used for years to estimate populations of vertebrate wildlife. Alterations of these techniques can also be used to delimit foraging territories and feeding site fidelity of subterranean termites. In a previous study (Su et al. 1984) we demonstrated that following placement of paper towels stained with a dye Sudan Red 7B into a single monitoring station or feeding site offfield colonies of the Formosan subterranean termite, the majority of foragers, collected from other interconnected stations of the same colony eventually acquired the dye **marker**. Spectrophotometric analyses of dye in each individual and counts of stained foragers indicated that foragers selected a feeding site at random among multiple established sites. We did not imply that foragers search for food in soil at random. Rather, once foraging sites are **established**, workers move among the feeding locations at random. Further these results indicate that foragers do not express feeding site fidelity; they move among the sites utilized by the colony. This study was conducted to ascertain whether a slow-acting toxicant could be placed in a single or few bait stations and be delivered to the majority of the foraging population. Our assessment of forager movement would support that hypothesis.

KEYWORDS: Random foraging, feeding site selection, mark-recapture, subterranean **termites**

COMPARISONS OF SINGLE AND GROUP BIOASSAYS ON ATTRACTION AND ARRESTMENT OF  
*RETICULITERMES SPP.* (ISOPTERA: RHINOTERMITIDAE)  
TO SELECTED CELLULOSIC MATERIALS

Steven B. Suoja, Vernard R. Lewis, David L. Wood, and Myles Wilson

Abstract

Arrestment and attraction behavior of single worker/nymph (>3rd instar pseudergates) and groups of ten subterranean termites. *Reticulitermes* were assayed in a no-choice laboratory arena. Four different cellulosic treatments: nondecayed Douglas-fir heartwood blocks (wet and dry), and Douglas-fir sapwood blocks (wet and **dry**) decayed by *Gloeophyllum trabeum* (Fr.) Muir. (= *Lenzites trabea*) were used in this investigation. Initial times of contact and total time of contact with treatments were recorded in 20-minute bioassays. There were no significant differences between levels of attraction to the treatments found with tennites locating all treatments in less than two minutes. When arrestment behavior was evaluated, termites spent significantly more time in contact with wet treatments when compared with **dry** treatments. This research has developed a simple bioassay that uses single termites to predicted group behaviors of attraction and arrestment toward cellulosic substrates.

THE ART OF ABOVE-AROUND BAITING OF *COPTOTERMES FORMOSANUS* SHIRAKI WITH  
**RECRUIT®** AG STATIONS

Julian R. Yates III and J. Kenneth Grace  
Dept. of Entomology, Gilmore Hall, 3050 Maile Way  
Honolulu, HI 96822

The Recruit® AG bait system, an above-ground system using hexaflumuron, was recently introduced to Hawaii as a remedial device to control the Formosan subterranean termite. Approximately two years of field trials were conducted on the islands of Oahu and Kauai to determine the efficacy and applicability of the system. Thorough knowledge of the biology and behavior of the Formosan termite and flexibility in developing methods for proper application of the bait stations are important. Twelve separate infestations at the Kauai site were controlled with the techniques described. When these stations were used outdoors, methods were developed to accommodate prevailing conditions such as precipitation and predators that can compromise the efficacy of the system. These factors became extremely critical when installations involved areas where it was not possible to install in-ground Recruit® stations.



WOOD CONSUMPTION AND FECAL PELLET PRODUCTION BY  
TWO DRYWOOD TERMITES (KALOTERMITIDAE)

1. K. Grace and R. T. Yamamoto

Department of Entomology, University of Hawaii at Manoa  
3050 Maile Way, Room 310, Honolulu, HI 96822

**ABSTRACT** *Cryptotermes brevis* (Walker) and *Incisitermes immigrans* (Light) nymphs were held either individually or in groups often for an eight-week period, and fed either filter paper, Douglas-fir, or Ponderosa pine. Total consumption was noted; and fecal pellet number, mass, and volume were recorded weekly. Solitary individuals defecated more and produced smaller fecal pellets than nymphs maintained in groups, although the total individual mass of feces produced was similar. Diet affected feeding, food utilization, and fecal pellet number and mass. Consumption and defecation reflected cellulose and lignin content of the substrate, with less ingestion of filter paper than wood on a weight basis, but greater utilization of the ingested paper (98%) and less fecal mass. The percentages of the ingested wood utilized (not excreted) were virtually equivalent for Douglas-fir and pine: 63% and 65% respectively with *C. brevis*. and 71% and 72% with *I. immigrans*. Each *I. immigrans* nymph consumed about 0.2 mg of wood each day, while each *C. brevis* nymph consumed slightly less than 0.15 mg of wood per day. On the average, nymphs of both termite species deposited from 0.7 to 1.0 fecal pellets per day, equivalent to a daily average fecal mass of 0.06 mg when fed Douglas-fir, and 0.05 mg when fed pine. Correlation of these data with population growth curves could permit estimation of the size and age of drywood termite colonies.

LABORATORY EVALUATION OF MICROWAVES FOR CONTROL OF THE WESTERN DRYWOOD  
TERMITE (ISOPTERA: KALOTERMITIDAE)

Vernard R. Lewis<sup>1</sup>, Michael I. Haverty<sup>2</sup>, and Ariel B. Power<sup>3</sup>

<sup>1</sup>Division of Insect Biology, Department of Environmental Science, Policy, and Management, University of California, Berkeley, CA 94720

<sup>2</sup>Chemical Ecology of Forest Insects, Pacific Southwest Research Station, USDA Forest Service, P.O. Box 245, Berkeley, CA 94701

<sup>3</sup>Forest Products Laboratory, University of California, 1301 South 46th St., Richmond, CA 94804

REFERENCE: Lewis, V. R., M. I. Haverty, and A. B. Power. 1998. Laboratory evaluation of microwaves for control of the Western Drywood Termite (Isoptera: Kalotermitidae). Proceedings of the National Conference on Urban Entomology, 1998.

ABSTRACT: Lethal effects of microwaves on the Western Drywood Termite, *Incisitermes minor* (Hagen), were evaluated under laboratory conditions. Douglas-fir two-by-four boards (28 cm long) artificially infested with 75 drywood termite workers, 25 in each of three routed-out galleries, were placed into ovens **rated** at 600, 1,100, and 2,100 watts. All ovens had the same wavelength frequency, 4 GHz. A **total** of 75 boards were prepared and treated, 25 per oven. Boards were randomly oriented within ovens and were treated with one of five treatment times (5 replicates per treatment time per oven). The treatment times varied with the wattage of oven and ranged from 20 to 150 seconds. The longest treatment time was chosen at the point just prior to ignition of the boards. Fifteen untreated control boards were also prepared to measure background termite mortality levels. All boards were opened 1-day post-treatment and counts made on live and dead tennites. Four week post-treatment counts were also made for survivors of the initial treatment. Termite mortality exceeded 80% for all treated boards 1-day post-treatment. At four weeks post-treatment, mortality levels for all treated boards exceeded 85%. Higher wattage ovens had higher termite mortality levels. However, the variance in mortality for treated boards was considerable, and for some treatments, exceeded 40% of the mean. None of the means for treated boards exceeded 95% mortality. The results suggest drywood termites can escape the lethal effects of microwaves. Although the exact mechanism of escape is not known, additional laboratory studies measuring changes in temperature of water vials confirmed unequal heat distribution within ovens. Results of this study support previously reported observations of variable termite mortality levels using commercial microwave devices for controlling drywood termite infestations in homes.

KEYWORDS: drywood tennites, *Incisitermes*, nonchemical control, thermal control

INJECTION OF SPINOSAD SC FOR THE CONTROL OF *CRYPTOTERMES BREVIS*  
(ISOPTERA: KALOTERMITIDAE) IN HARDWOOD SHIPPING PALLETS

R. J. Woodrow and J. K. Grace  
Department of Entomology, University of Hawaii at Manoa  
3050 Maile Way, Room 3 10, Honolulu, HI 96822

**ABSTRACT** Infested wooden shipping pallets were collected from Naval warehouses. Pallets were divided into ' groups according to the level of infestation (low, medium, or **high**) based on the number of infested boards present. Prior to chemical treatment, baseline readings were taken with an acoustic emissions detector (AED) in all pallets at 30 cm intervals, up to four individual readings per board. Spinosad SC was injected at a concentration of 0.5% in either 1, 2, or all of the AED monitoring locations on each of the infested boards. Control pallets received no treatment. Monthly post-treatment AED readings were taken for 5 months. At the conclusion of the post-treatment period one pallet was randomly selected from each treatment and extracted to determine the presence of living drywood termites relative to AED monitoring locations.

There was an immediate and significant reduction in AED counts in pallets treated with spinosad as compared with untreated controls at one month and throughout the remaining post-treatment period. There were significant reductions in AED counts in untreated as well as treated locations throughout treated pallets at five months indicating possible movement from untreated areas into treated areas and thus providing evidence that Spinosad was not repellant to *C. brevis*.

Live termites were found in treated as well as untreated pallets at the conclusion of the test. However, in locations with spinosad residue there were significantly less live termites and large quantities of dead termites as compared to areas without residues. Termites **remaining** in treated boards could have resulted from an inability of the AED to locate all termite infestations in the pallets, or indicate that more time was required for all termites to contact the insecticide residue.

## PREVENTION OF DRYWOOD TERMITE INFESTATION WITH DISODIUM OCTABORATE TETRAHYDRATE

RudolfH. Scheffrahn, Nan-Yao Su, Jan Krecek, Boudanath Maharajh, and Gregory S. Wheeler  
University of Florida, Ft. Lauderdale Research and Education Center  
3205 College Avenue, Ft. Lauderdale, FL 33314

*Cryptotermes brevis* alates established nuptial chambers and incipient colonies in wooden "trap-block" bioassays . during the 1996 flight season. Crevices in trap blocks were the preferred loci for nuptial chamber construction. No-choice tests were conducted with trap blocks treated on crevice sides, outer sides, or all sides with 15% disodiwn octaborate tetrahydrate (DOT) solution or water. Live dealates, heterosexual dealate pairs, and brood were detected in all no-choice water treatments at 6 mo. The mean number of nuptial chambers and live termites was not significantly different among the three water treatments. The number of nuptial chambers in trap blocks was significantly lower in all DOT treatments compared with water-treated blocks and no live termites were found in any DOT-treated blocks. These findings demonstrate that aqueous surface deposits of DOT are deterrent to dealates, and partial treatment of trap blocks with DOT is sufficient to inhibit colony foundation by *C. brevis*.

Additionally in 1996, amorphous silica gel dust with synergized pyrethrins or DOT dust were applied to trap block tops and tested against water-treated blocks in choice tests. Significantly lower numbers of nuptial chambers and live termites were detected in silica gel-treated blocks compared to paired water-treated blocks. No live termites were detected in either DOT or DOT-paired water treatments suggesting that dealates searching for colonization sites were intoxicated by DOT dust and unable to found colonies in neighboring water-treated blocks.

CONTROL OF WESTERN DRYWOOD TERMITES (*INCISITERMES MINOR*, Hagen)  
WITH SPINOSAD IN CALIFORNIA, 1996

Robert E. Williams  
Technical Service & Development  
Professional Pest Management  
Moorpark, CA

Ellen M. Thoms  
Technical Service & Development  
Professional Pest **Management**

D. Michael Chambers  
Product Development **Manager**  
Professional Pest **Management**  
Indianapolis, IN

ABSTRACT

Spinosad 4SC (NAF-85) diluted to 0.5% in water was evaluated for the control of western drywood termites (*Incisitermes minor*, Hagen) in California during 1996. **Twenty-one** separate tennite colonies from 13 different structures distributed among 5 California communities were identified and randomly assigned to one of three treatments: (1) injection application into active galleries at 30-cm hole spacing; (2) injection application into active tennite galleries at 60-cm hole spacing; or (3) untreated control. Feeding activity was measured before treatments and at monthly intervals up to 4 months post-treatment using an acoustic emissions detector (AED). While untreated control feeding activity across 8 infestations increased by an average of 50% at 1-month post-treatment, feeding activity across 7 and 5 infestations treated at 30-cm and 60-cm spacing, respectively, correspondingly averaged about 90% reduction. No difference in percent AE counts was observed between the infestations treated at the two spacings. Subsequent post-treatment feeding activity in the untreated control infestations at 4-months **post-treatment** declined to about 29% below pre-treatment levels, presumably due to normal fall-season decline. Corresponding feeding activity in the treated infestations declined to about 97% below pre-treatment levels. In conclusion, spinosad at 0.5% provided excellent control of drywood termites in California when injected into active galleries. Considering that the 60-cm spacing treating was applied to somewhat larger infestations and used significantly greater quantities of spinosad, it is difficult to clearly state that spacing of the injections is not an important effect. However, it is clear that both spinosad treatments significantly reduced AE counts at post-treatment intervals.

## SELECTIVE THERMAL CONTROL OF GERMAN COCKROACHES USING SPATIAL ANALYSIS TO IDENTIFY POPULATION FOCI

Brian C. Zeichner, and Alfred Lynn Hoch  
U.S. Army Center for Health Promotion and Preventive Medicine  
Aberdeen Proving Ground, Maryland 21010-5422

Heating food service facilities to a target temperature of 115°F for 45 minutes has proven to be an **effective** means of controlling chronic, unacceptable, insecticide resistant German cockroach populations. The advantage to heat as a control method is that it penetrates all equipment harborages, thus impacting the entire population. Following thermal control, cockroach populations have remained extremely low for up to at least 2.5 years in some facilities. However, heating the entire facility is disruptive to food service operations and labor intensive.

Spatial analysis is a statistical tool that analyzes trap data and produces population contour maps. These maps provide a means of identifying population foci that serve as reservoirs for cockroach repopulation. In many instances, it is a relatively small area of the facility that serves as a source for repopulation following control measures. The ability to identify these foci and apply heat selectively to those areas would derive the benefits of thermal control with much less cost and disruption to the facility.

Techniques were developed to effectively heat selected pieces of equipment and small areas. Various heaters, tenting methods, insecticide adjuncts, and cockroach containment devices were **evaluated**. **Common**, inexpensive materials proved effective for tenting and containment. The most effective heater was a 400,000 Btu, direct-fired propane unit with an output of 2,000 cubic feet per minute.

The infestation patterns observed during selective thermal control treatments have correlated extremely well with that predicted by spatial analysis. We believe that spatial **analysis** has the ability to identify infestation foci remaining after conventional control efforts and that the selective application of heat to those foci is a viable and valuable pest control alternative.

The opinions or assertions contained herein are the views of the authors and are not to be construed as official or as reflecting the views of the Department of the Army or the Department of Defense.

**SMOKYBROWN COCKROACHES: WHERE DO WE PUT  
TRAPS AND HOW MANY DO WE NEED?**

Lane M. Smith and Arthur G. Appel  
Department of Entomology  
Auburn University, AL 36849

Abstract not available .

DAILY TRAP-CATCH DYNAMICS OF GERMAN COCKROACHES  
(DICTYOPTERA: BLATTELLIDAE) IN KITCHENS.

Arthur G. Appel  
Auburn University

Age-specific trap-catch of **German** cockroaches, *Blattella germanica* (L.), was evaluated with Mr. Sticky™ traps in infested kitchens continuously for 7d. Over 75% of all cockroaches and, in general, more of all stages were caught in traps positioned at the stove and refrigerator. Using profile analysis, the number of daily new captures **did** not change over **time** at most trap locations, indicating that **previously** caught cockroaches were neither attractive nor repellent. However, new captures near the refrigerator declined over time probably because of localized trapping **out**. Refrigerators appeared to be better **harborage** areas compared with other locations. Putative harborage areas in kitchens can be identified by examination of sticky trap catch. There is greater catch and a lower ratio of gravid female to other stages at **harborage** areas than other locations in infested kitchens. Except for traps located next to **harborages**, daily trap catch can be estimated by dividing total catch by the number of days the trap was in place.



# SMOKYBROWN. COCKROACHES AND THEm. ENVIRONMENT: TREES, BUSHES, GROUND COVER, MAN-MADE STRUCTURE, AND SPATIAL EFFECTS

Lane M. Smith and Arthur G. Appel  
Department of Entomology, 301 Funchess Hall  
Auburn University, AL 36949-5419

The smokybrown cockroach, *Periplanetafuliginosa* (Serville), is the most common peridomestic cockroach throughout the southeastern U.S. The importance of different habitat elements relative to its abundance **has** been investigated by several researchers and commented on by several extension scientists. However, the importance of different habitat elements has not been investigated in detail.

Sampling 107 houses in 1994, we measured cockroach activity with jar **traps** six times (July through September) and collected several other data sets that described the habitat at each house: namely, geographic location of homes, species of trees within 10 m of homes (canopy diameter, trunk diameter, and number of trees), species of trees 10 - 20 m from a house, species of bushes along the perimeter of a house (number of clumps, and clump area), **ground** cover (within 10 m of a house), **ground** cover (within 10-20 m., from a house), distance of neighboring homes (within 100 m), structure within 10 m of a house (e.g., walls, out-buildings., woodpiles, etc.). structure within 10-20 m of house, characteristics of house (e.g., age, facing, size, etc.), insecticide spray regime, and activity of other arthropods as measured in jar traps.

Spatial dependence of cockroach activity is low, describing less than 10% of variation in activity. Tree characteristics, bush characteristics, and other insects were highly correlated with activity (30-60 %), **ground** cover was moderately correlated (25%), whereas house characteristics and insecticide regime were poorly correlated (10-20%) Nearness of neighbors was not significantly correlated with cockroach activity.

Variables were also correlated with each other. This meant that when the effects of other variables were partialled out, some variables were no longer significantly correlated with cockroach activity (e.g., house characteristics and insecticide regime). Total correlation between all variables and cockroach activity did not exceed 80%.

Correlation studies do not necessarily demonstrate causal effects, because not all appropriate variables may have been measured. However, this analysis demonstrated that vegetation and ground cover are significantly correlated with cockroach activity even after removing house characteristics, structure variables, insecticide spray regime, and activity of other arthropods. The low percentages of variation described uniquely by any set of variables also highlights possible interactions between variables and those potential effects on cockroach activity. This study represents the most thorough understanding of smokybrown cockroach habitat in the southeast, especially when experimental manipulation of many variables would be considered highly undesirable by homeowners (e.g., cutting down trees) or prohibitively expensive (e.g., planting large trees or bushes, removing or adding to house structure).

## **COCKROACH IPM: FACT OR FICTION?**

Mike S. Chapman  
Western Exterminators  
Irvine, CA 92714

Abstract not available .

PATHOGENICITY OF *METARHIZIUM ANISOPLIAE* STRAIN ESC-1 TO GERMAN  
COCKROACHES AND ITS COMPATIBILITY WITH INSECTICIDES

Pari Pachamuthu and Shripat T. Kamble  
Department of Entomology, University of Nebraska  
Lincoln, NE-68583-0816

The entomopathogenic fungus, *Metarhizium anisopliae* (Metchnikoff) Sorokin, is a potential microbial agent that can be used as a component of an integrated pest management approach. Each potential strain has to be tested individually to determine the impact on the target pest. If a strain is found to be effective, then the efficacy can be further improved by incorporating the microbial agent with insecticides. The first objective of this study was to determine the lethal dose of *M. anisopliae* strain ESC-1 to male German cockroaches. The second objective was to determine the compatibility between the strain ESC-1 and insecticides (chlorpyrifos, propetamphos and cyfluthrin) by in vitro procedure. Germination, colony growth and sporulation were the three parameters used for determining the compatibility between the two agents. The lethal dose was determined using concentrations of *M. anisopliae* ranging from  $8 \times 10^7$  to  $2 \times 10^9$ . The  $LD_{50}$  was  $4.18 \times 10^8$  spores/ml (i.e.,  $4.18 \times 10^5$  spores/cockroach). The in vitro compatibility study was conducted using the following concentration, 500, 50, 5 and 0.5 ppm for chlorpyrifos & propetamphos and 50, 5, 0.5 and 0.05 ppm for cyfluthrin. Conidial germination was found to be compatible at all concentration tested for the three insecticides but colony growth and sporulation was significantly affected. Diameter of the colonies growth cultured on media amended with 50 and 500 ppm of chlorpyrifos, and 500 ppm of propetamphos treatments at 3, 6 and 9 d was significantly reduced in comparison to the control (partial inhibition). Sporulation was affected significantly in those treatments that exhibited partial inhibition. The colonies cultured on SDAY media amended with 50 ppm chlorpyrifos had significantly reduced sporulation as compared to the control but colonies cultured on media amended with 500 ppm of chlorpyrifos and propetamphos had no sporulation.

## THE RAPID EMERGENCE OF RESISTANCE TO CERTAIN INSECTICIDES IN THE GERMAN COCKROACH

Donald G. Cochran<sup>1</sup>, Professor Emeritus  
Department of Entomology  
Virginia Polytechnic Institute & State University  
Blacksburg, VA 24061-03 19

A review of the literature reveals that resistance to several insecticides commonly employed for the control of the German cockroach has emerged after relatively short periods of usage. This is somewhat surprising considering the fact that gene frequency estimates as low as  $10^{-3}$  to  $10^{-6}$  have been suggested for populations not previously exposed to a particular insecticide (Roush and McKinzie 1987). Reasons for this rapid emergence of resistance are not entirely clear. Among the possibilities are that, in each case, the major gene involved was widely distributed in field populations prior to the use of that insecticide and was present at relatively high frequencies. The opportunity to examine **this** possibility arose in the case of resistance to cypenethrin. It has been shown that this trait is controlled by one major, autosomal, incompletely recessive gene (Ebbett and Cochran 1997). Toxicological testing by the tarsal contact method using a rate of  $1.5 \text{ nl/cm}^2$  of cypenethrin kills all homozygous susceptible and heterozygous individuals. Only homozygous-resistant individuals survive a 24 h exposure at **this** rate and their numbers can be quantitated in a test population (Cochran 1994). This makes it possible to estimate gene frequency in such populations using the Hardy-Weinberg equilibrium expression (Falconer 1981). I have made gene frequency estimates using data collected from cypermethrin tests on 80 field-collected populations of German cockroaches. The results showed that in 57 of these populations the gene frequency was above 0.20 and ranged from 0.20 to at least 0.99. When gene frequencies were in the 0.20-0.45 range, resistance ratios were usually well below 3.0. When gene frequencies exceeded 0.50 resistance ratios increased rapidly to **very** high levels. In the other 23 populations the gene for cypenethrin resistance was either absent or was present at frequencies below 0.20, which was the lowest value I could detect with the sample sizes I used. From this work, I have concluded that the gene for cypermethrin resistance is widely distributed in field populations of German cockroaches, and is present at levels high enough to explain the rapid emergence of resistance.

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### KEYWORDS

German cockroach, cypermethrin resistance, gene-frequency estimates, field-collected populations

<sup>1</sup>Current address: 1205 Kings Landing Road, Hampstead, NC 28443

RELATIONSHIP BETWEEN INSECTICIDE RESISTANCE LEVEL  
AND DETOXICATION ENZYME ACTIVITY IN THE GERMAN COCKROACH:  
CAN SURROGATE SUBSTRATES BE USED TO DETECT RESISTANCE?

Steven M. Valles

USDA-ARS, Center for Medical, Agricultural and Veterinary Entomology,  
Gainesville, Florida 32608

Historically, insecticide resistance detection has been accomplished by insecticide bioassay. This method is labor intensive and incapable of detecting resistance frequencies below 10%. An alternative to bioassay is detection of metabolic resistance through quantification of detoxication enzyme activities toward surrogate substrates. For example, naphthyl esters have long been used to identify hydrolytic detoxication mechanisms in mosquitoes, aphids and similar small bodied insects. Although enhanced metabolism is a major mechanism of insecticide resistance in German cockroaches, the relationship between insecticide resistance level and detoxication enzyme activity toward surrogate substrates has not been explored. Therefore, oxidative, hydrolytic, and conjugative detoxication enzyme activities were measured in 10 German cockroach strains collected recently from the field and exhibiting a range of resistance levels to several pyrethroid insecticides in an attempt to identify relationships that could be exploited for the purpose of detecting insecticide resistance.

Resistance levels at the LD<sub>50</sub> value varied from 3- to >200-fold in topical bioassays compared with the Orlando susceptible strain. Among the 10 strains, resistance was typically greatest to cypermethrin. All strains exhibited statistically higher cytochrome P450 content, aldrin epoxidase, methoxyresorufin O-demethylase, and glutathione S-transferase (CDNB substrate), and general esterase activities as compared with the insecticide susceptible Orlando strain. However, no direct relationship was noted between cypermethrin resistance level (or LD<sub>50</sub> value) and cytochrome P450 content ( $R^2=0.26$ ) aldrin epoxidase ( $R^2 = 0.15$ ), methoxyresorufin O-demethylase ( $R^2 = 0.34$ ), or glutathione S-transferase activity ( $R^2 = 0.094$ ). General esterase (toward the substrate *Pnpa*) did result in a moderately good relationship with pyrethroid resistance ( $R^2 = 0.76_{\text{cypermethrin}}$ ). Perhaps with the exception of general esterase, these results indicate that surrogate substrates provide a poor indication for the presence of metabolic pyrethroid resistance in the German cockroach.

KEYWORDS

German cockroach, *Blattella germanica*. resistance detection, detoxication

COMPARISON OF ESTERASES BETWEEN RESISTANT CRAWFORD AND  
SUSCEPTIBLE CSMA STRAINS OF GERMAN COCKROACH  
(DICTYOPTERA: BLATTELLIDAE)

No-Jong I. Park and Shripat T. Kamble  
Department of Entomology, University of Nebraska-Lincoln  
Lincoln, NE 68583-0816

The Crawford strain showed very high level of resistance to **cypermethrin**, propoxur, and pennethrin with RR values of 17.26, 15.75, and 13.53, respectively and increasing level of resistance to chlorpyrifos with RR value of 5.62 against CSMA strain. Esterase activity between resistant Crawford and susceptible CSMA strains were compared with the substrates of  $\alpha$ - and  $\beta$ -naphthyl acetate (NA) according to the sexes and nymphal age classes. Activities of  $\alpha$ -NA and  $\beta$ -NA esterase in Crawford strain were significantly higher than those activities in CSMA strain at both nymphal and adult stage. In Crawford **strain**, the enzyme activity at nymphal stage was also significantly higher **than** adults but such difference was not observed in CSMA strain. The esterase isozyme **analysis** with **native** polyacrylamide gel electrophoresis was also conducted to determine the quantitative and qualitative difference between them. The isozymes, *a* and *c* in the bottom of the lane were more intensely stained in every developmental stages and sexes of both strains and these isozymes showed much greater activity in Crawford strain. Another highly stained isozyme *b* was observed only in the homogenate from Crawford strain. The combination of the isozyme *b* and the overproduced isozyme *a* and *c* in Crawford strain seems to be responsible for the difference in total esterase activity between CSMA and Crawford strains.

## JUVENILE HORMONE: REGULATOR OF REPRODUCTION AND FEEDING IN THE GERMAN COCKROACH

Glenn L. Holbrook, Ted E. Snyder, and Coby Schal  
Department of Entomology, North Carolina State University  
Raleigh, NC 27695-7613

The reproductive cycle of the female German cockroach, *Blattella germanica*, has been well characterized. Upon emerging as an adult, a female will feed intensively for several days, mate, and then oviposit up to 50 eggs which she carries in an egg case for about three weeks at 27°C. Juvenile hormone, the major product of insect corpora allata, is the master regulator of female reproduction. Females that are surgically deprived of these glands fail to develop their oocytes and do not oviposit. However, if surgically excised glands are re-implanted into females they proceed to reproduce. Food is another essential factor for reproduction. Females that are starved from adult eclosion do not reproduce. In our research we have investigated the interplay between juvenile hormone and food in regulating German cockroach reproduction. We have examined the role of feeding in stimulating juvenile hormone synthesis by the corpora allata. Most importantly, however, we have investigated whether juvenile hormone influences feeding. The ultimate objective of our research has been to determine whether juvenile hormone analogs can promote the efficacy of toxic baits.

The results of our current research can be summarized as follows:

Figure 6. Juvenile hormone stimulates female feeding: When newly emerged adult females are topically applied with the juvenile hormone analog, fenoxycarb, they exhibit enhanced feeding in the first three days following the treatment.

2) Juvenile hormone regulates female feeding: Females that have been allatectomized exhibit decreased feeding, but when these females are topically applied with 1 µg fenoxycarb their feeding is restored to near normal levels in the first three days after the treatment.

3) Juvenile hormone analog increases the efficacy of toxic baits: When hydroprene and Combat® (hydrarnethylnon) were used in conjunction, the degree of cockroach control in apartments was substantially greater than when either agent was used alone.

4) Juvenile hormone inhibits male feeding: Males topically applied with fenoxycarb exhibited decreased feeding for the initial week after treatment. Thereafter feeding was unimpaired.

These results clearly show the great potential for using juvenile hormone analogs to enhance the efficacy of toxic baits. Nevertheless, the inhibition of male feeding by juvenile hormone analogs will require further study.

## PLAGUED BY FLEAS: A CLOSER LOOK AT THE CALIFORNIA GROUND SQUIRREL

Marco E. Metzger and Dr. Michael K. Rust  
Department of Entomology, University of California  
Riverside, California 92521-0314

The California ground squirrel, *Spermophilus beecheyi* (Richardson), is a reservoir of bubonic plague throughout most of its range. There are 3 species of fleas that occur on these animals during the year; *Oropsylla montana* (Baker), *Hoplosyllus anomalus* (Baker), and the ubiquitous sticktight flea, *Echidnophaga gallinacea* (Westwood). It is believed that *Oropsylla montana* is responsible for most cases of plague transmission to humans and domestic cats, while the roles of the remaining two species in plague epidemiology is less clear. California ground squirrels are a highly versatile species which flourish in disturbed urban landscapes, often in close **proximity** to homes. The sticktight flea is an opportunistic pest which readily infests domestic dogs and cats and frequently requires control measures. Additionally, the continued expansion of urban development in southern California has put increasing numbers of people in high risk foothill areas where plague is endemic in rodent populations. Despite the importance of these fleas to public health, there is only limited **information** regarding their biology, ecology, and how this might influence their effective control.

Wild squirrels were trapped on the UC Riverside campus. The animals were deparasitized, blood tested for disease, and individually maintained in tub-style guinea pig cages. A novel nesting-box was designed and assembled from which flea eggs could easily be collected without removing or handling the animal. Eggs were reared to adults on artificial **media**. Using this technique, all three species have been successfully colonized in the laboratory on their natural hosts. Studies have focused on the development and survivorship of these fleas exposed to different temperature and relative humidity combinations similar to those reported from inside squirrel burrows. Survivorship from egg-to-adult varied for each flea species under different conditions. Results with *H. anomalus* and *E. gallinacea* suggested that these are more xeric-adapted species than *O. montana*. Average egg hatch of *H. anomalus* and *E. gallinacea* was substantially reduced at 31.5% RH and no larvae survived more than 48 hrs at less than 55% RH. In contrast, *O. montana* was highly susceptible to desiccation when reared at less than 75% RH, with none surviving at less than 65% RH. The developmental time of all species increased with lower temperatures and RH. Our initial results corroborate reported seasonal shifts in adult flea abundance inside burrows and on wild squirrels.



## ABSENCE OF SYSTEMIC ACTIVITY IN PYRIPROXYFEN FED FLEAS

Roger Meola, Kristin Meier, and Susan Dean  
Department of Entomology, Texas A&M University  
College Station, TX 77843

For the second time, the activity of pyriproxyfen in the blood diet was investigated for its efficacy against adult, egg, and larval stages of the cat flea. Fleas were fed pyriproxyfen in bovine blood using an artificial membrane system which allows fleas to feed ad libitum through a parafilm membrane. Controls received blood without pyriproxyfen. Results of the first test were presented last year at the International Symposium on Ectoparasites of Pets. At that time I reported that 80-90% of the fleas died when they were fed pyriproxyfen for 10 d at concentrations ranging from 1 to 10 ppm compared with 25% mortality in the controls. Subsequent research now indicates that those results were incorrect possibly due to cage contamination. The purpose of this presentation is to correct this error and to point out some interesting differences between the systemic and residual effects of pyriproxyfen in adult fleas.

Results of our current study indicated that pyriproxyfen was relatively non-toxic to adult fleas over a period of 10 d when ingested in blood at concentrations as high as 100 ppm. These findings are in sharp contrast to earlier studies which showed that residues of pyriproxyfen on filter paper or dog hair were highly toxic to adult cat fleas. The fleas obviously fed on the blood containing pyriproxyfen because they produced large numbers of eggs. However, none of the eggs hatched even when fleas were fed concentrations of pyriproxyfen as low as 1 ppm. Larvae from eggs laid by untreated fleas also failed to develop into adults when fed fecal blood excreted by pyriproxyfen-treated fleas. These results suggest that pyriproxyfen may be partially metabolized when fed to adult fleas, reducing the concentration below the level that is toxic to a high percentage of the test population. Alternatively, fleas exposed to the same concentrations of pyriproxyfen in blood may eat less chemical than they absorb from residues on filter paper or dog hair. Even though ingested pyriproxyfen was relatively non-toxic to adult fleas, evidently enough of the chemical was still absorbed through the gut wall to cause ovisterilant activity, while the remainder was excreted.

## DAILY AND SEASONAL VARIATIONS IN SOIL TEMPERATURES AROUND STRUCTURES WITH SLAB FOUNDATIONS

Harry N. Howell Jr. and Roger E. Gold  
Department of Entomology, Texas A&M University  
College Station, TX 77843

Thermocouples were placed at the soil surface, at 30 cm deep in the soil and under the foundation slab of frame structures in Brazos County, TX. Temperatures at these points on the north, east, south and west sides of the structures were recorded during a 24-hour period monthly. For reference, the **air** temperature, and the surface and sub-surface temperatures away from the structure were also recorded.

On the north, west and **east** sides of the structures, the soil temperatures varied indirectly in relation to the **air** temperature. On the south side, the sub-slab temperature was also indirectly related to the **air** temperature while the surface and sub-soil temperatures on that side varied directly with the **air** temperature. At the location away from the building, the surface temperatures were directly proportional to the **air** temperature while the sub-soil temperature was indirectly related. There were day-night effects noted.

EVALUATION OF EFFICACY AND RESIDUES OF CYPERMETHRIN AND PERMETHRIN USED IN  
FIELD TESTS ON STRUCTURES IN TEXAS.

Mark S. Wright, Roger E. Gold, and Harry N. Howell  
Department of Entomology, Texas A&M University  
College Station, TX 77843-2475

**ABSTRACT:** Twenty homes with existing subterranean termite (Isoptera: Rhinotennitidae) infestations were treated by a commercial termite control operator in Texas City, TX. One half (10) of the homes had been previously treated with chlordane. Ten homes were treated with permethrin **and** cypermethrin tenniticide at 0.75% and 0.25% respectively. Analytical/biological samples from treated areas around the foundation were collected at **tank** mixing, pre-treatment, 7 days, 1 year, and 2 years post-treatment. This soil was analyzed by gas chromatography to determine the concentrations of tenniticide present **and** by biological assay to determine **if** any bioactive termiticides were present. The resulting soil tenniticide concentrations varied greatly from sampling point to sampling point around the same **structure**. When a failure to control termites was encountered, a retreatment with the same pesticide was affected. At the end of the 1st year post treatment, 50% of the cypermethrin treated homes had termite reinfestation; **and** at the end of the 2<sup>nd</sup> year 40% of the cypermethrin treated homes had termite reinfestations. Only one of these nine homes tested to have a low level of cypermethrin at the point of penetration. At the end of the 1<sup>st</sup> year 20% of the permethrin treated homes had termite reinfestation and at the end of the 2<sup>nd</sup> year 10% of the homes had reinfestation. One of these homes was the same home that had penetration at the end of the 1<sup>st</sup> year. All of the permethrin treated homes had more than adequate concentrations of tenniticide to be repellent.

# ANALYSIS OF SOIL PROPERTIES IN RELATION TO TERMITICIDE PERFORMANCE IN LOUISIANA

Gregg Henderson<sup>1</sup>, P. Mark Walthall<sup>2</sup>, Beverly A. Wiltz],  
Victor H. Rivera-Mornor, David R. Ganaway<sup>2</sup>, and H. Magdi Selim<sup>2</sup>  
[Department of Entomology, LSU Agric. Ctr., Baton Rouge, LA 70803  
2Department of Agronomy, LSU Agric. Ctr., Baton Rouge, LA 70803

<sup>3</sup>Department of Experimental Statistics, LSU Agric. Ctr., Baton Rouge, LA 70803

**ABSTRACT:** Nineteen soil types representing a range of Ph, organic **carbon**, and clay content, were evaluated for termiticide efficacy using five termiticides in constant exposure assays on Formosan subterranean termites. Three different rates were evaluated for each compound. There were significant differences in mortality with respect to soil type, termiticide, and treatment rate.

The three pyrethroids and one organophosphate tested were highly efficacious at label rates and, in some cases, below label rates. Cypermethrin at 100 parts per million (ppm) **had** reduced efficacy against Formosan subterranean termites, *Coptotermes formosanus* Shiraki, in high clay, high organic content soils. **Deltamethrin** and chlorpyrifos were compromised only at very low rates (5 ppm). Deltamethrin was affected most by high organic soils. Chlorpyrifos efficacy was affected by high Ph and high clay soils. Permethrin at 100 ppm **had** mortality effects with increasing organic **carbon**.

**Key words:** Bioavailability, Formosan subterranean termites, soils, Ph, organic content, clay, termiticide

**INTRODUCTION** The success of termiticides in stopping termites from entering structures is well known and remains an essential part of termite control. However, when soil conditions fall outside an optimum range, termiticides can be immobilized or adsorbed by the soil or altered chemically to an inactive form. Biological activity (bioavailability) of termiticides against the Eastern subterranean **termite** *Reticulitermes flavipes* (Kollar) is reduced in sandy clay loam soils compared with sandy loam and sand (Forschler and Townsend 1996). Likewise, clay soils apparently bind organophosphates and make them less **available** to contacting tunneling Western subterranean termites, *R. hesperus* Banks (Smith and Rust 1993). Moreover, aged soils, especially those that pose bioavailability problems, can also affect residual activity of termiticides (Famashiro et al. 1987, Gold et al. 1996a). With retreatment rates of termite barrier treatment contracts reaching 15-20% across the United States (Shaneen 1998), it **has** become ever more critical to evaluate the interaction of currently registered termiticides and soil binding characteristics.

The purpose of this study was to identify specific soil properties that inactivate termiticides. Soils from several geographic areas of Louisiana were collected and characterized for organic **carbon** content, percent **clay** and Ph. A subsample of these soils that represented the broadest spectrum of possible combinations was used for bioassays against Formosan subterranean termites, *Coptotermes formosanus* Shiraki. Five termiticides that **are** currently on the market, or soon will be, were bioassayed at several rates, six weeks posttreatment.

## Materials and Methods

Eighty-eight soil samples were collected from locations throughout Louisiana (Figure 1). The levels we used to define Low, Medium, and High for organic carbon, clay, and Ph are provided in Table 1. Approximately 3 kg of soil surface material were collected at each sample location. The soil samples were sealed in plastic bags and characterization analyses were conducted at the LSU Agricultural Center, Agronomy Department. Soils were characterized according to clay content, organic carbon and Ph.

From the original 88 soil samples, 19 were selected that represented all soil characteristics found (Table 1). To determine soil moisture content for each soil type, approximately 100 g of each soil was placed into a 250 ml glass jar and weighed. The soils were then left uncovered for 24 hours at room temperature and dried in a 60 deg C oven for an additional 24 hours. Soils were again weighed and the percent moisture calculated.

Five termiticides were used for treating the soils: **Dragnet**<sup>®</sup> FT (36% permethrin, FMC Corporation, Philadelphia, PA, lot 1612-074), Deltagard TC (22.8% deltamethrin, AgrEvo Environmental Health, Montvale, NJ, lot 25850B), Dursban TC (42.8% **chlorpyrifos**, Dow AgroSciences, Indianapolis, IN, lot LC04161602), **Demon**<sup>®</sup> TC (25.3% cypermethrin, Zeneca Inc., Wilmington, DE, lot 232650926 TR), **Premise**<sup>®</sup> 75 (75.0% imidacloprid, Bayer Corporation, Kansas City, MO, batch 7 85 7022). Each jar received one of the following treatments: Dragnet (50Oppm, 100ppm, 5ppm, or Oppm), Deltagard (125ppm, 50ppm, 5ppm, or Oppm), Dursban (500ppm, 100ppm, 5ppm, Oppm), Demon (250ppm, 100ppm, 5ppm, or Oppm), Premise (100ppm, 5Oppm, 5ppm, or Oppm). (Figure 2 illustrates the experimental design). All chemicals were mixed in a solution of 0.01N **CaCl<sub>2</sub>**, 0.1 N triethanol amine, and 0.005N **DTPA**, buffered at Ph 7.3. Controls only received this solution. Treatments were made at a 1:1 ratio, by weight, of the soil to liquid. After **adding** the chemical, the soil was stirred with a **plastic** spoon until all of the soil was wet. The jar containing the soil and liquid was then weighed and all jars were left uncovered at room temperature in the laboratory. Two weeks after treatment, while the soils were still moist, they were stirred with metal spatulas. After an additional two weeks, the soils were stirred with putty knives.

## Termite bioassays

Five weeks after treatment, soils were prepared for bioassays on Formosan subterranean termites. Approximately thirty grams of soil from each jar was finely ground with a mortar and pestle. Five grams were then placed into each of six plastic Petri dishes (60 mm x 15 mm), for a total of 2280 dishes (6 replicates x 19 soils x 20 treatments).

One week later, termites were extracted from two *C. jormosanus* colonies collected about 1 month prior to starting this experiment, in New Orleans, LA (colony "A" and colony "B"). At the same time, each Petri dish was gently shaken to evenly distribute soil over the bottom and 1ml deionized distilled H<sub>2</sub>O was pipetted onto the soil in each dish. Twenty-five termites (ca. 10% soldiers) were added to each dish and the dishes were then covered and left on the countertop at 28 deg C. For each treatment, replicates 1, 2, and 3 received termites from colony A, and replicates 4, 5, and 6 received termites from colony B.

Twenty-four and 48 hours after placing the termites on the soil, mortality was recorded as the proportion dead. For those dishes where mortality was 100% after 24 hours, no observation was made at 48 hours. Three days after adding the termites to the dishes, all dishes except those containing Premise treated soil and the controls associated with Premise treatments were placed in cardboard boxes in a -18 deg C dark incubator. Premise treatments and their controls were evaluated again at 5 days due to this chemical's unique properties (slow action) as a termiticide.

Percent mortality results were transformed (arcsin of the square root of the percent mortality) and a 3-factor factorial (factors: soil **type**, termiticide, and rate) was performed using the mortalities recorded after 24 and 48 h of exposure (SAS Institute, version 6.11, Cary, North Carolina). Premise also was evaluated separately from the other termiticides at day 5. Linear contrasts were used to evaluate differences among treatments. At specific concentrations where soil properties influenced termiticide efficacy a simple effect analysis (decomposing interactions) was used to test differences in mortality in relation to soil properties.

## Results

At 24 and 48 hours there were significant differences in all factors evaluated and in all interactions of those factors (Tables 2 and 3). For Premise, at day 5, there was a significant difference among soil **type** and rate, as well as the interaction of the two. However, Premise was not considered in further analysis because we believe the experimental design was not appropriate for this chemical. Specifically, at day 5, mortality in controls for some soil types was high and evaluation of termiticide treatment with soil type was confounded by time related desiccation of termites.

A graphical representation of 48 h results for the other chemicals is provided in Figures 3 through 6. Twenty-four hour results were similar. Dragnet was affected by soil type and had a reduced mortality at 100 ppm. At this rate, high organic soils affected termiticide efficacy most. Demon was also affected by soil type at the 100 ppm level. With this termiticide, both increasing organic matter and clay content **appeared** to affect **termiticide efficacy**. At 5

ppm there was no difference from control for either Demon or Dragnet and little mortality was observed at 24 or 48 hours. Deltagard showed no soil effects on termiticide efficacy at 125 ppm or 50 ppm, but soil effects on termiticide efficacy were found at 5ppm. Clay and organic matter were both implicated in binding the chemical at this low concentration. Dursban was the only chemical (and only organophosphate evaluated) to show a Ph effect. High Ph and high clay soils treated at 5 ppm showed reduced termite efficacy.

## Discussion

At **label** rates, soil type did not affect termiticide activity on Formosan subterranean termites in constant exposure bioassays. It was not until termiticide levels fell far below label rates that effects of organic carbon, clay, and Ph were observed. Bioavailability of termiticide was reduced when low rates of termiticides were applied to high clay, high organic, and, in one case, high Ph soils. Degradation of termiticides also is most apparent in alkaline soils with high clay content and organic content (Gold et al. 1996b). In addition, soil termiticide levels generally fall to concentrations of about 100 ppm two or more years posttreatment (Gold et al. 1996a). These facts, coupled with the above results of bioavailability, increase our awareness of the potential interactions termiticides have with soil in affecting termite mortality. An equal amount of treated soils used in this study was saved for a repeat of the experiment at one year posttreatment. In this case we expect to see the interaction of bioavailability and degradation with respect to termiticide effects on Formosan termites. These laboratory results should be treated with caution when attempting to relate them to field situations.

## Acknowledgments

We thank the Louisiana Pest Control Association, and in particular, Mr. Rene Bourgeois, Ms Lois Stevens, and Mr. Allen Fugler, for providing direction in early planning and in soliciting funding for this project. We thank Dr. Brian Forschler for reviewing the draft proposal and providing valuable advice that improved this study. Zeneca, FMC and AgrEvo provided much needed financial support and are acknowledged. The Louisiana Department of Agriculture and Forestry provided funds for research help that aided this project.

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Table 1. Combination of soil characteristics used in the termiticide inactivation experiments. Soil samples were obtained throughout the state of Louisiana during the period of February-June 1997. L=Low, M=Intermediate, H=High.

Organic Carbon

L=0.0-1.3%    M=1.47-2.6%    H=2.7-3.9%

Clay

L=0.0-22%    M=23-44%    H=45-66%

pH

L=4.0-5.6    M=5.7-7.2    H=7.3-8.8

SoilID	Clay	pH	Organic Carbon
10	L	L	L
50	L	L	M
73	L	L	H
90	L	M	L
NU*	L	M	M
33	L	M	H
85	L	H	L
91	L	H	M
NF	L	H	H
5	M	L	L
1,72	M	L	M
NF**	M	L	H
24	M	M	L
86	M	M	M
89	M	M	H
NF	M	H	L
34	M	H	M
NF	M	H	H
NF	H	L	L
NF	H	L	M
2	H	L	H
NF	H	M	L
79	H	M	M
70	H	M	H
23	H	H	L
65	H	H	M
NF	H	H	H

\*NU-observed but not used in experiments

\*\*NF=not observed

Table 2. ANOVA table for constant-exposure bioassays performed in August 1997. Duration of experiment was 24 hours.

Source	OF	Sum of Squares	F ratio	Prob>F
SoilId	18	11.145	27.999	0.0001
Termiticide	4	231.243	2548.844	0.0001
Rate	3	605.377	8896.884	0.0001
SoilId*Termiticide	72	13.043	7.987	0.0001
Soil Id*Rate	54	14.495	11.835	0.0001
Termiticide*Rate	12	175.104	643.351	0.0001
Soil Id*Termiticide*Rate	216	49.876	10.18	0.0001

Table 3. ANOVA table for constant-exposure bioassays performed in August 1997. Duration of experiment was 48 hours

Source	DF	Sum of Squares	F ratio	Prob> F
SoilId	18	31.253	36.1	0.0001
Termiticide	4	145.657	757.1	0.0001
Rate	3	638.486	44249	0.0001
Soil Id*Termiticide	72	29.174	84	0.0001
Soil Id*Rate	54	24.722	9.5	0.0001
Termiticide*Rate	12	134.516	233.1	0.0001
Soil Id*Termiticide*Rate	216	79.393	7.6	0.0001



Figure 1. The distribution of soils collected (n=88) in Louisiana and their frequency with respect to having low, medium, or high, Ph, clay, and organic carbon content.

Figure 2. Schematic of experimental design used to evaluate treated and untreated soils against Formosan subterranean termites.

Figure 3. Three-dimensional representation of interaction of soils having low, medium, or high Ph, clay, and organic carbon treated with Deltagard on mortality (1=100%) of Formosan subterranean termites.

Figure 4. Three-dimensional representation of interaction of soils having low, medium, or high Ph, clay, or organic carbon treated with Demon on mortality (1=100%) of Formosan subterranean termites.

Figure 5. Three-dimensional representation of interaction of soils having low, medium, or high Ph, clay, and organic carbon treated with Dragnet on mortality (1=100%) of Formosan subterranean termites.

Figure 6. Three-dimensional representation of interaction of soils having low, medium, or high Ph, clay, and organic carbon treated with Dursban on mortality (1=100%) of Formosan subterranean termites.

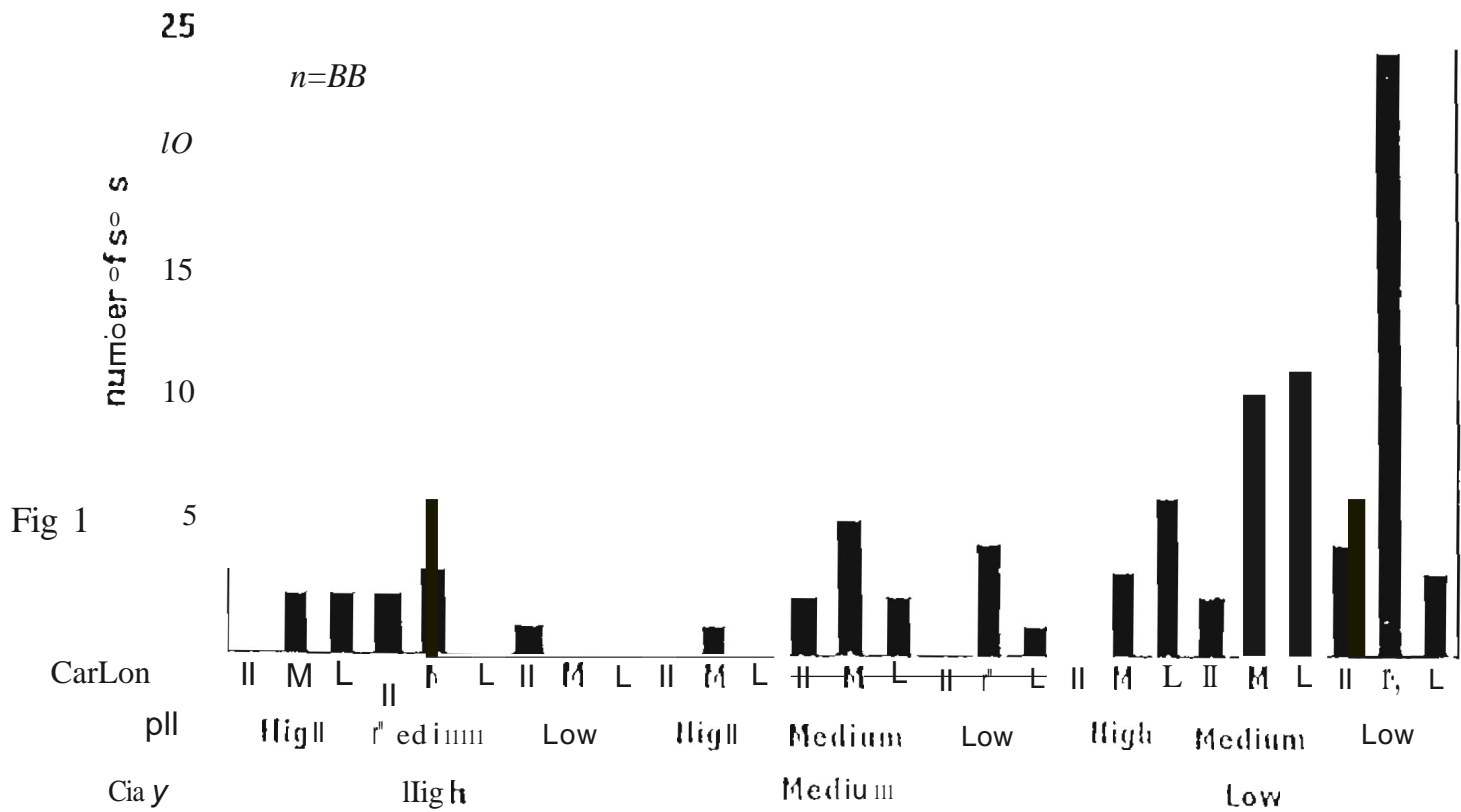
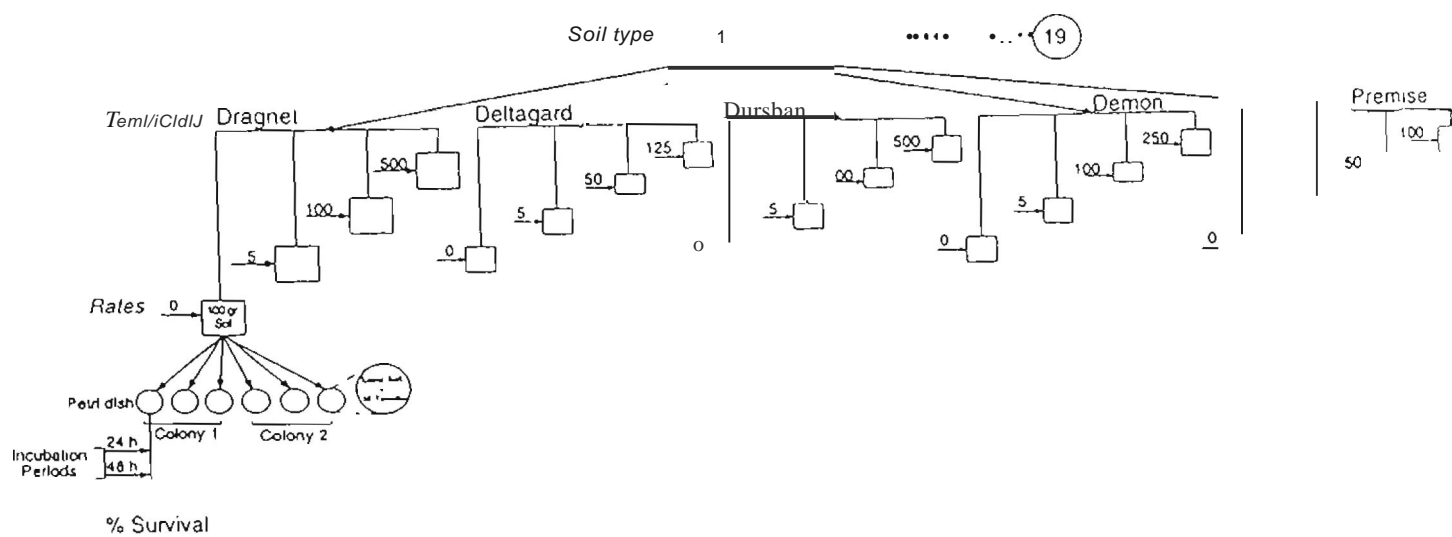


Figure 2



# Deltagard,

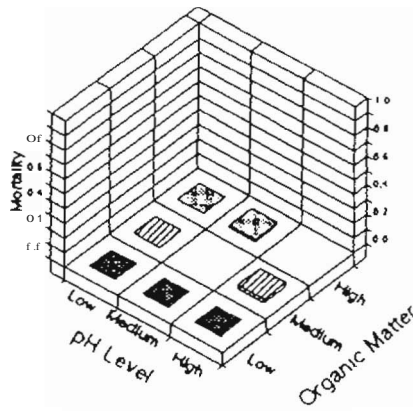
Fig 3

Low Clay,

Medium Clay,

High Clay.

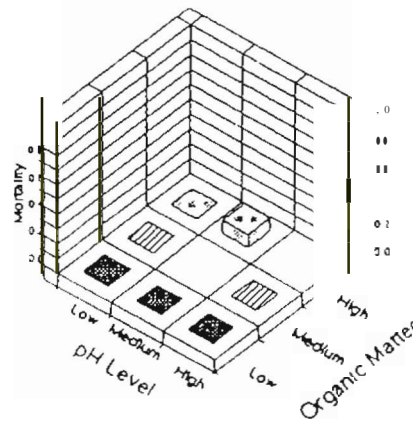
Control.



Mortality

Mortality

5 (ppm)



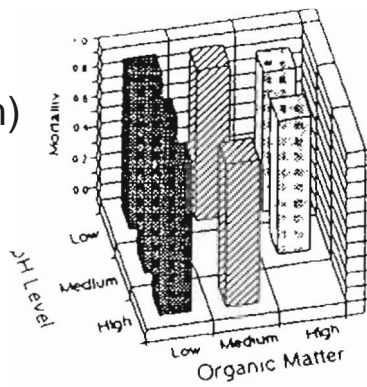
Mortality

High  
Medium  
Low  
Organic Matter

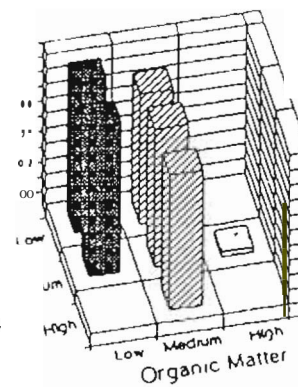
Mortality

High  
Medium  
Low  
Organic Matter

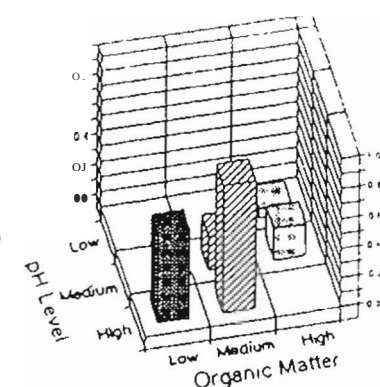
50 (ppm)



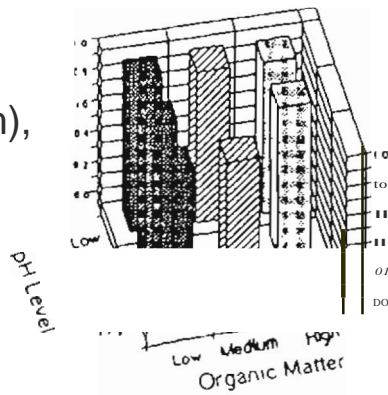
pH Level



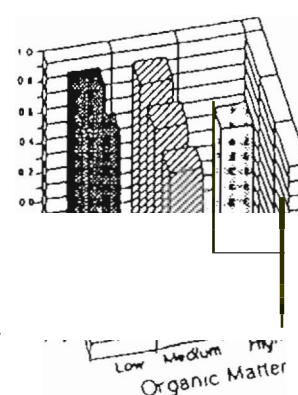
pH Level



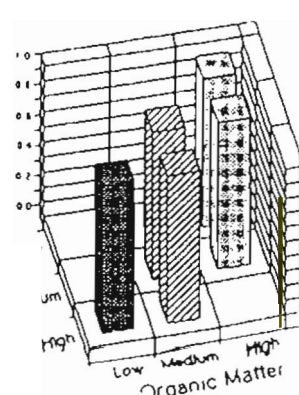
125 (ppm),



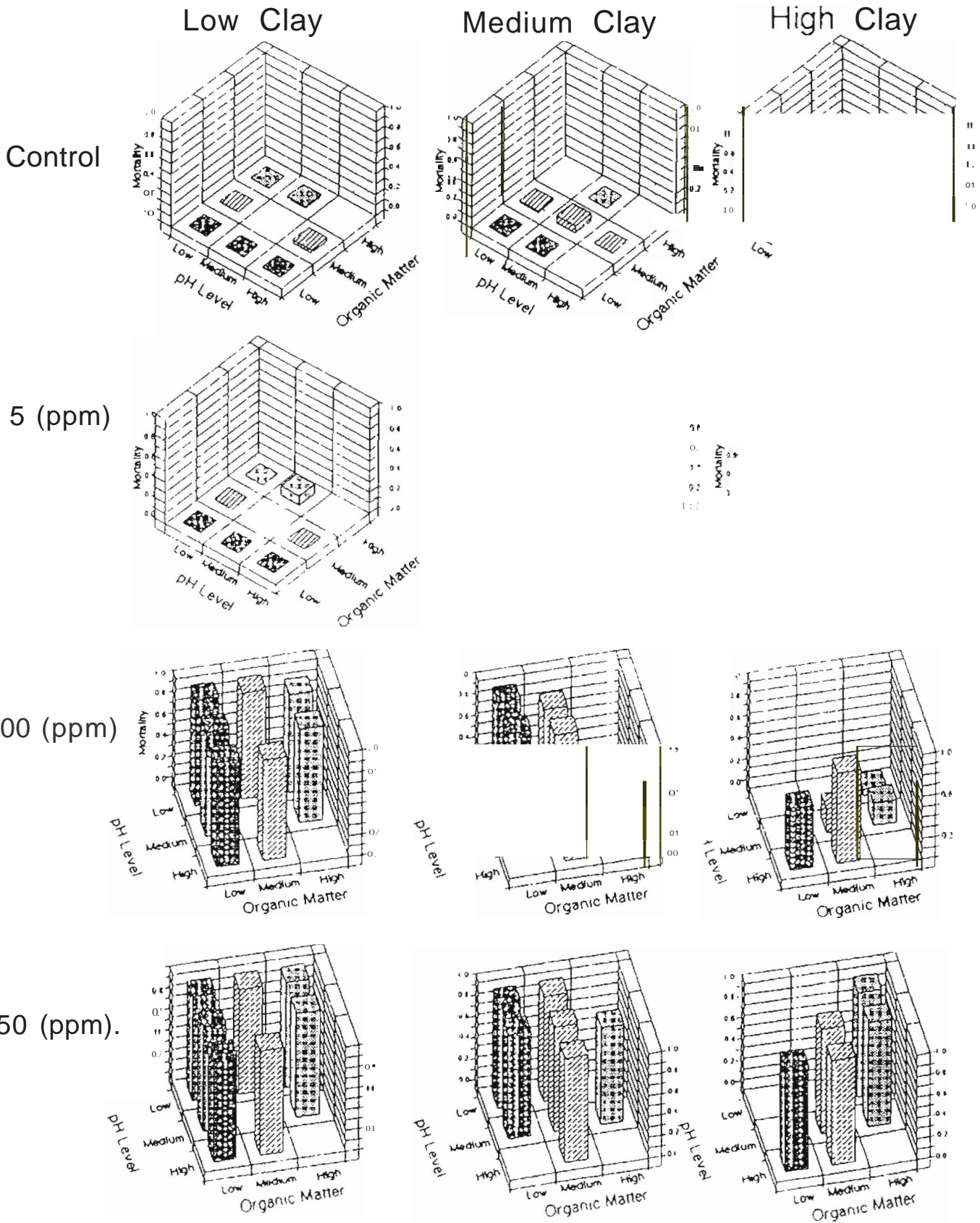
pH Level



pH Level



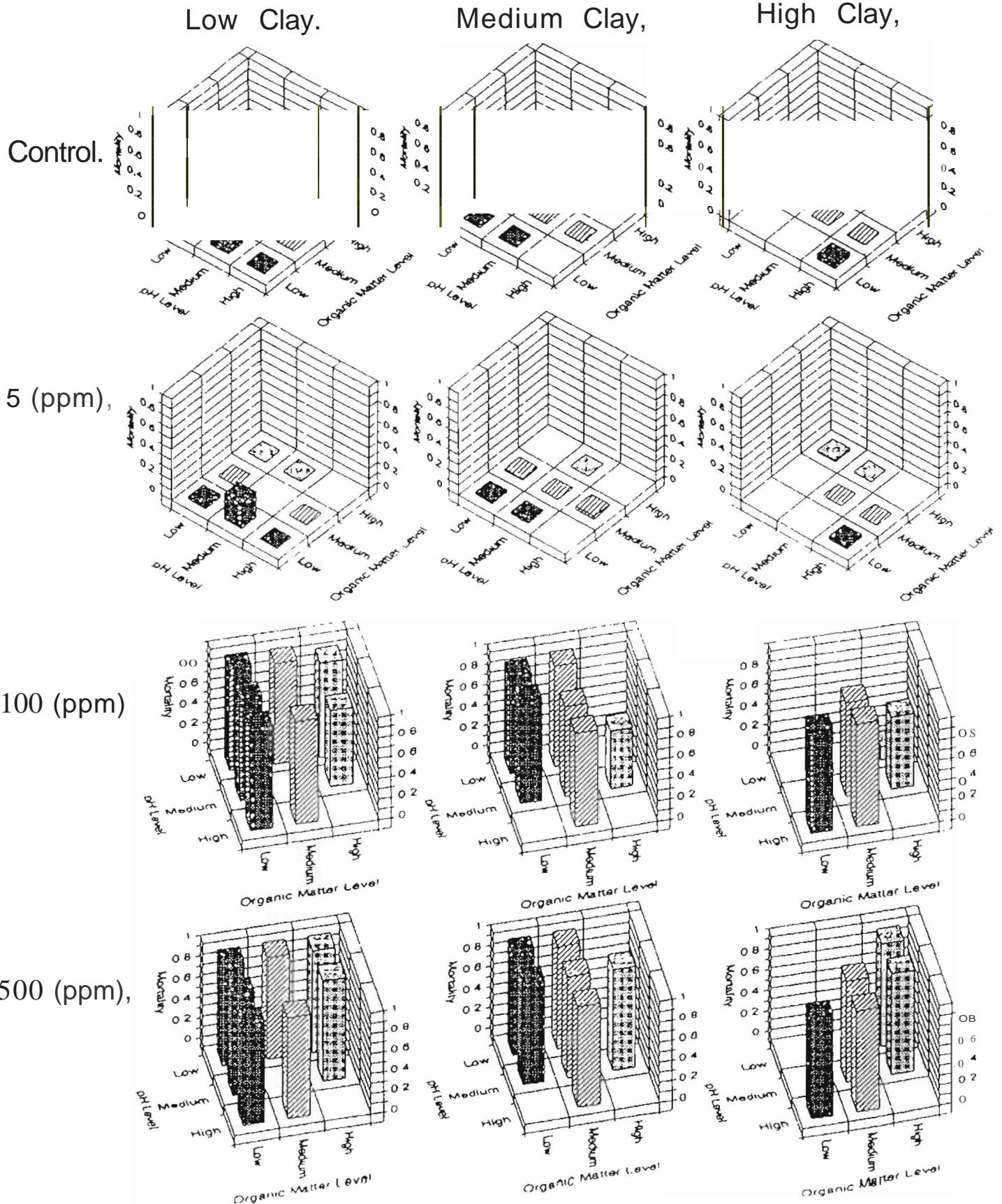
# Demon



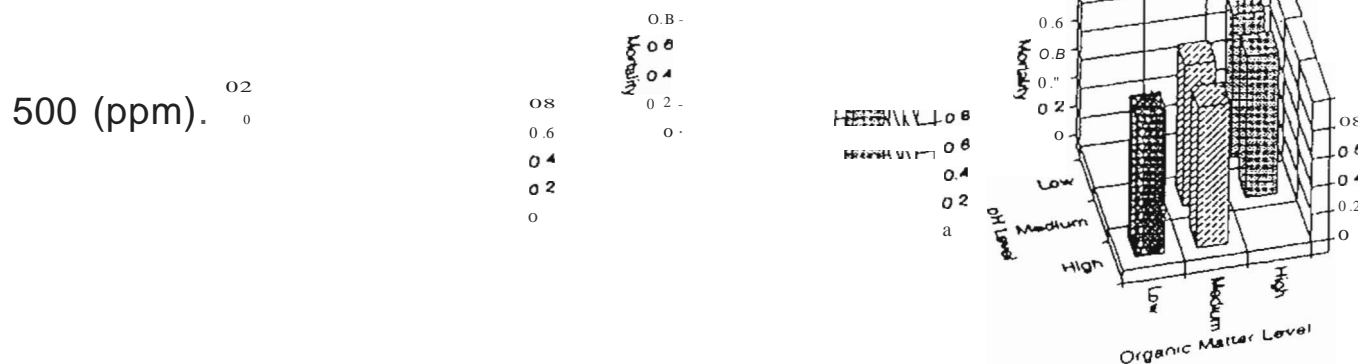
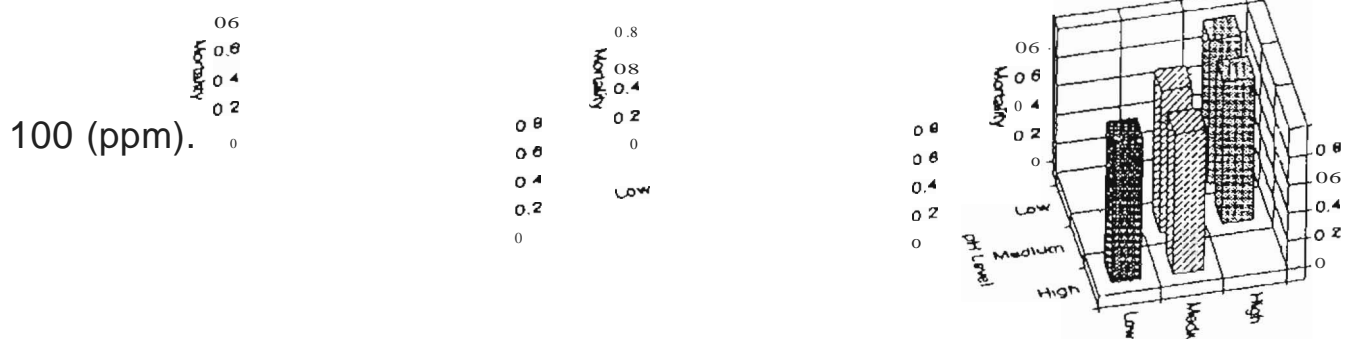
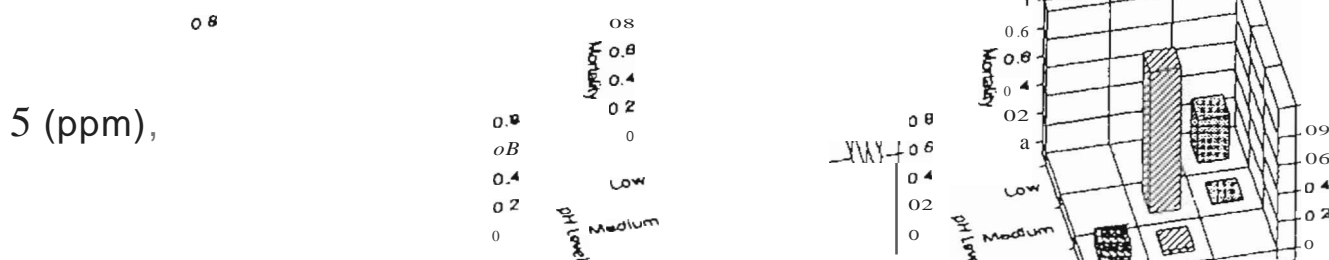


# Dragnet

Fig )



## Fig6



**FAUNA FOUND WITHIN IN-GROUND SUBTERRANEAN TERMITE  
MONITORING AND BAIT STATIONS IN SOUTHERN CALIFORNIA  
AND THEIR IMPACT ON TERMITE CONTROL**

**Hanif Gulmahamad**  
Terminix International  
1501 Harris Court,  
Anaheim, CA 92806

Abstract not available ... ..

## CHARACTERIZE PEST POPULATIONS AS A BASIS FOR PEST MANAGEMENT DECISIONS IN FIELD SITUATIONS

Jeffrey A. Weier  
Sprague Pest Control

Using Population Mapping and Contributing Environmental Factors to P.O. Box 2222  
Tacoma, WA 98401

One of the current problems in urban entomology has been to make effective pest management decisions that provide adequate control of pests. Our approach uses pest population mapping to characterize pest populations and monitoring environmental factors to predict pest outbreaks. These techniques have been used in a variety of situations for several different pests. One example is at a paper mill where flying aquatic insects were contaminating food-grade coated paper by becoming incorporated during its manufacture. Over a four-year period the insect captures of 136 insect light traps in four different areas were analyzed using spatial analysis to identify areas of high insect concentration. The results of these analyses, in the form of contour maps, were used to determine entry points, reduce attractive lighting and modify work practices that allow insects to enter the mill. In addition river water temperature and air temperature were monitored and compared to light trap captures and paper contamination. Based on these comparisons it was determined that water temperature was the critical factor relating to paper contamination. Action thresholds were developed based on river water temperature and exterior light trap capture levels. Previously, regular applications of insecticides were used in an attempt to prevent insect entry into the mill. As a result, insect contamination in the paper was reduced by 56%, insecticide use was reduced by 99% and direct pest control costs were reduced by 45% the first year and these reductions have been maintained in subsequent years.



# MONITORING WITH SUGAR WATER TO DETERMINE THE EFFICACY OF TREATMENTS TO CONTROL ARGENTINE ANTS, *LINEPITHEMA HUMILE* (MAYR)

Donald A. Reiersen, M. K. Rust, and J. Hampton-Beesley  
Department of Entomology, University of California  
Riverside, CA 92521-0314

The Argentine ant is one of the most widespread pest and nuisance ant species in the United States. Most abundant in California from about June to December, Argentine ants seasonally forage proteins and carbohydrates, presumably in relation to brood production. Often having many satellite colonies (polydomous), there **may** be millions of Argentine ants per hectare at the peak of the season. They are notable by their trailing **behavior** and their propensity to find food quickly and recruit nestmates. Foraging trail traffic may exceed 500 per min. *L. humile* is troublesome not only as a periodic nuisance invader of homes where it tends to seek sweets, but also as a serious secondary pest on ornamental plants and in agriculture where it prevents natural enemies from suppressing aphids and other honeydew-producing insects. Considered a tramp species, unabated *L. humile* **may** affect the ecology of sensitive areas by preying **upon** vulnerable ground-bound pollinators and other insects.

## Materials and Methods

A study was made during the summer in 1997 in Riverside, CA to determine the efficacy of barrier sprays and baits to control Argentine ants around homes. Rather **than** based on numbers of ants counted, efficacy was calculated from the adjusted weight loss of 50% (wt/vol) sucrose sugar water presented to the ants in twelve 20-ml polypropylene monitoring tubes before and after treatment. Based on laboratory study, foraging *L. humile* imbibe an average of 0.3 mg sugar water per visit, essentially doubling their foraging weight. About 15 ml, more sugar water **than** would usually be **taken** per day was loaded into each tube. The tubes were placed no closer than about 7m from one another. Loss of weight from the tubes was corrected for evaporation of liquid and drowned ants. The adjusted weight loss value made it possible to estimate the number of ant visits per station, and to map areas of greatest foraging. Using a series of such pre-weighed stations at residences, comparative statistical analyses of treatment efficacy was made. One value of such monitoring is **that** it reflects long-term foraging (i.e. 24-hr) and does not depend on singular **momentary** observations which may vary greatly with time of day and environmental condition.

Study sites were solicited by campus wide mailing, and verification of *L. humile* was made at each site. Barrier sprays at homes were applied from a 50-gal commercial power sprayer at the rate of 10 gal per 100 ft<sup>2</sup>, measured with a flowmeter. Liquid baits consisting of insecticide in 50% sugar water were evaluated in a nearest neighbor tree test in which pairs of trees 35 to 50 meters apart and with foraging trails of *L. humile* coursing their trunks were used in pairs; bait being dispensed at the base of one and the other serving as an untreated control. Liquid baits were dispensed from a single capped 50-ml plastic vial laid flat on the ground and from which a cotton wick extending into the liquid protruded to serve as a feeding surface for the ants. Each vial initially contained 40 ml bait. One vial of bait was placed at the base of each test tree and were protected under inverted clay plant pots. Bait was left in place continuously and was replaced if depleted or if the liquid or wick became moldy. Boric acid and fipronil (technical, 97.3% and a 0.2% commercial concentrate, Nexa Lotte<sup>®</sup>) were evaluated. Efficacy was calculated from the reduction in ant visits, based on sugar water weight loss from a series of pre-weighed tubes.

## Results and Discussion

Riverside is located 85 Km inland, separated by low mountains from desert. Summer day temperatures often exceed 40°C (104°F) and <20% RH. Argentine ants in Riverside foraged virtually year-long on sucrose sugar water. High % sucrose was accepted best by the ants and evaporated more slowly **than** low %. Greatest foraging intensity in terms of volume of sugar water taken per day was directly related to observed ant trail traffic. Although summertime foraging occurred to some extent during both days and nights, foraging was intense and more consistent after sundown and was less affected by environmental condition, especially high temperature. Good acceptance of sugar water made it possible to quantify the efficacy and persistence of outdoor treatments by measuring ant reduction in the amount of sugar water taken by ants over time.

Monitoring at Homes. Tables 1 and 2 show typical results of monitoring treatments for Argentine control with sugar water. Using two rates of **Alert**<sup>®</sup> SC (chlorfenapyr), monitoring indicated greater efficacy with higher rate of application, as would be expected. We were startled that the high number of estimated ant visits/residence/24h (176,000 to 538,000) did not correlate with incidents of ant invasion indoors. Chlorfenapyr, 0.1% provided significant reduction of ant activity for more than 2 weeks, and chlorfenapyr, 0.25% provided relevant and statistical reductions for the 60-day study. Based on past experience, most treatments in the harsh Riverside summer environment would not remain effective much longer than 30 days. In a much smaller pilot comparison test at only 3 homes with 0.06% cypermethrin (Tempo 20WP) applied in the same fashion, results were less consistent and in two instances ants became bothersome indoors after treatment, presumably because of the repellent nature of the Tempo barrier. Results of monitoring two of the Tempo treatments are summarized in Table 3.

Sugar water monitoring suggests that early season sprays may keep foraging ants at bay, even if the active ingredient is highly repellent. Monitoring also suggested that nearby stepping stones, trees and garbage areas outside the spray barrier should be treated because those sites may serve as sources of reinvasion. Sugar water monitoring may help identify nearby sites that should be treated.

Monitoring at Trees. Provided the trees were sufficiently far apart from one another, selected paired trees proved to be good study sites for determining the activity of baits against foraging *1. humile*. Logistically, this was superior to evaluating baits at homes because more replicates could be quickly evaluated. Sustained high numbers of foraging ants on the paired unbaited tree assured that decline at the baited tree was attributable to bait rather than to natural factors. Monitoring with sugar water was done at the base of trees where boric acid, 0.5% [AI] and fipronil at  $1 \times 10^{-3}$  and  $1 \times 10^{-4}$ % were dispensed as baits. Counts of ants coursing the trunks of trees generally directly correlated with take of sugar water from monitoring tubes placed at the base. This relationship gives credibility to sugar water monitoring tubes reflecting ant activity at homes.

Based on sugar water take, one-day ant visit counts at trees ranged from 22,127 to 67,900. Boric acid provided an average decline of only 31.8% at 30 days and 34.6% at 60 days post-bait even though large amounts of bait were foraged by the ants. As reflected by take of sugar water, there was complete kill at 3 of 10 trees at 30 days and at 5 of 10 trees at 60 days. There was virtually no reduction at the other tree sites baited with boric acid. Such extremes of results suggest that bait efficacy may be related to colony size, structure, or behavior. Because bait was presented *ad libitum*, it is unlikely that ants from nearby unbaited territory moved onto baited trees; invading ants would be as susceptible to the bait as were the ants that succumbed.

Fipronil,  $1 \times 10^{-5}$ % was effective against *1. humile* in laboratory assays, but higher rates were marginally effective in this study in that ants were not totally eliminated. Technical fipronil,  $1 \times 10^{-3}$ % provided an average reduction at 30 days of 54.4%. Diluted commercial preparation (Nexa Lotte) provided 53.0% at 30 days. As with boric acid, there was complete cessation of foraging on some trees baited with fipronil liquid (II of 22 trees), but foraging was apparently unaffected at the others. Presence of dead ants at bait dispensers suggests that  $1 \times 10^{-3}$ % fipronil may be too concentrated to be effective as a bait, producing kill of foragers before being fed to non-foraging members of the colony. AI on dispenser wicks may have become even more concentrated by evaporation.

This study showed that monitoring overnight with sugar water is a good way to quantify the presence of Argentine ants. Sugar water consumption provides a reliable and convenient tool for quantifying the efficacy of ant control treatments. Coupled with marking techniques, such monitoring may also help identify the chronology and geography of reinvasion of treated areas. Obviously, such monitoring is not recommended for species that do not forage carbohydrate on a consistent basis. Additional studies with sugar water monitoring of *1. humile* are planned for 1998.

#### Acknowledgments

We thank Eileen Paine for assisting in preparation of samples, for weighing monitoring vials, and for spreadsheet data entry and interpretation. We also thank American Cyanamid Company, Bayer Corporation, and Rhone-Poulenc Ag Company for financial assistance and insecticides for the study.

Table 1. Efficacy of 0.1% Alert<sup>1</sup> 2SC (chlorfenapyr) applied as a perimeter barrier spray against Argentine ants, *Unepithema humife* (Mayr).

Location	Area spray ed (ft <sup>2</sup> )	Rate of application		Precount <sup>s</sup> (No. ant visits)	% Reduction in ant visits at dayb			
		Gal	Gal/100 ft <sup>2</sup>		7	14	30	60
21499	1,06	12.5	1.2	487,027	49.5	40.8	5.8 *	disc.
Blossom	8				ns	ns		
6155	1,67	18.0	1.1	184,955	90.3 *	52.3	3.5 ns	disc.
Bluffwood	2					ns		
3419	848	9.8	1.2	197,648	85.3 *	96.5 *	0.0 ns	disc.
Kentucky								
575	1,44	14.4	1.0	342,973	92.5 *	98.6 *	71.3 *	disc.
Highlander	0							
830 S.	2,81	20.0	0.7	496,671	82.1 *	94.3 *	98.9 *	disc.
University	1							
1531 Ransom	1,96	20.5	1.0	246,764	76.1	73.7 *	73.9	disc.
	0				ns		ns	
12887	1,44	15.3	1.1	306,625	95,3 *	93,7 *	4.3 ns	disc.
Adelane	0							
CBN House	1,49	16.4	1.1	401,397	94.3 *	83.5 •	23.1 •	disc.
	6							
21486	1,20	9.5	0,8	538,067	96.2 *	65.4 •	14.9 •	disc.
Blossom	0							
21451	1,19	9.5	0.8	240,670	72.0 •	35.7	0.0 ns	disc.
Blossom	0					ns		
21475	1,19	10.3	0,9	434,124	48.5	51,0	0.0 ns	disc.
Blossom	0				ns	ns		
Series (n = 11) avg. % reduction					80.2 *	71.4 *	26.9	

<sup>1</sup>Visit calculated from weight of 50% sucrose solutions taken in 24 hours from up to 12 monitor stations per residence; each ant forages 0.3 mg per visit

bAsterisk (\*) indicates statistically significant reduction (P<0.05; Wilconon Signed-Ranks Test); ns = not significant; NA = residence not available for evaluations; disc. = discontinued.

Table 2. Efficacy of 0.25% Alert' 2SC (chlorfenapyr) applied as a perimeter barrier spray against Argentine ants, *Linepithema humile* (Mayr).

Location	Area spray ed (ft <sup>2</sup> )	Rate of application		Precount <sup>B</sup> (No. ant visits)	% Reduction in ant visits at dayb			
		Gal	Gal/100 ft <sup>2</sup>		7	14	30	60
3188 Wendell	2,023	20.5	1.0	288,020	99.6 ..	91.9 ..	81.8 ..	84.6 *
3391 Utah	836	9.1	1.1	175,789	89.3 ..	27.3 ns	0.0 ns	0.0 ns
3429 Florida	836	10.9	1.3	360,580	95.7 *	99.4 ..	89.8 *	86.7 ..
890 Blaine	836	9.0	1.1	398,699	97.3 ..	96.0 ..	NA	71.0 ..
4308 Kentucky	836	8.9	1.1	519,539	87.9 ..	86.0 *	81.8 ..	94.0 *
231 E. Blaine	1,456	12.5	0.9	340,392	94.7 ..	84.9 ..	87.4 *	71.0 ..
417 Alta Mesa	1,448	12.0	0.8	345,744	99.5 *	86.9 ..	99.2 ..	85.4 ..
453 Glenhill	1,912	13.7	0.7	455,925	91.9 *	95.4 ..	99.8 *	88.9 ..
760 Blaine	1,464	14.0	1.0	378,963	93.1 ..	88.2 ..	84.8 *	77.2 *
Series (n = 9) avg. % reduction					94.3 ..	83.9 ..	78.0 ..	73.2 ..

Table 3. Efficacy of Tempo 20 WP applied as a perimeter barrier spray against Argentine ants, *Unepithema humile* (Mayr).

Location	Area spray ed (ft <sup>2</sup> )	Rate 'of application		Precount& (No. ant visits)	% Reduction in ant visits at day <sup>b</sup>			
		Gal	Gal/100 ft <sup>2</sup>		7	14	30	60
UCR Parking	1,64	18.9	0.87	156,797	15.1	0.0 ns	0.0 ns	0.0 ns
	a				ns			
5072 Trojan	1,55	15.6	1.00	399,790	79.6 ...	77.1 *	75.4 ...	0.0 ns
	2							
Series (n = 2) avg. % reduction					47.4	38.6	37.7	0.0

**BALANCING ACT: EXPECTATIONS OF EXTENSION SPECIALISTS WITH URBAN  
RESPONSIBILITIES.**

Faith M. Oi  
Auburn University, Department of Entomology and  
Alabama Cooperative Extension System

**ABSTRACT:** Extension specialists with urban responsibilities are subject to broad expectations from the various client groups they must serve. These client groups include county agents, pest control operators, homeowners, and colleagues and University administrators when tenure is a consideration. Survey data will indicate the expectations for each of these client groups, presented in conjunction with the percentage of time urban Extension Specialists spend on each of these tasks.

## THE ROLE OF EXTENSION SPECIALISTS IN DEALING WITH DELUSORY PARASITOSIS

Naney C. Hinkle  
Department of Entomology, University of California  
Riverside, CA 92521

Delusory parasitosis is the attribution of sensations such as paresthesia, pnuitus, and urticaria to "bugs" when there is, in fact, no arthropod involvement. In the narrow sense, it is an emotional disorder in which the patient is convinced that tiny, almost invisible insects or mites are present in or on his body (Goddard 1996).

While arthropod activity can cause irritation to **humans**, similar sensations can be produced by myriad other conditions. Once the determination is made that there is no arthropod involvement, the condition is termed "delusory parasitosis" and the situation is no longer within the scope of entomological expertise, but appropriately devolves to health care professionals. The function of entomologists is to determine whether insects or mites are involved and, if so, to determine their identity and **make** recommendations for their suppression.

### Entomologists' Experiences with Delusory Parasitosis

Cooperative Extension Specialists in 47 states were surveyed regarding proportion of time spent dealing with delusory parasitosis. Urban and medical/veterinary entomology Specialists spend an average of 24% of their time on delusory parasitosis (range 0. 1-20%). While many survey respondents indicated that they dealt with only a dozen or so delusory parasitosis cases each year, they emphasized that each case takes an inordinate amount of time, typically involving several phone calls, examination of numerous samples, and multiple office visits.

### Survey of Delusory Parasitosis Complainants

In a retrospective study of delusory parasitosis cases (16 letters, 6 e-mail, 3 phone), the following generalizations were noted. Contact with the Specialist occurred 3 weeks to 15 years following onset of symptoms (median and mode = 3 months).

While 36% demonstrated no temporal distinction, 52% of complainants said the pests were active exclusively at night. In 80% of the cases, only a single individual was affected (in 12% two were, and 3 or 4 were in the other 8%). Over 60% claimed to be able to see the causative organism, which they identified as "insects" in 24% of the cases, as "bugs" in another 24%, and "mites" in another 24%. Additionally, the pests were called "parasites," "lice," "fuzz," "dust," or specifically "Collembola."

Symptoms included paresthesia (32%), pnuitus (24%), and a biting sensation (24%). Over 80% of the respondents had seen a physician, with a quarter of them having seen more than 1 (and one admitting to having visited 15). A dermatologist was specified by 25% of those who had seen a doctor.

Some 56% of those surveyed had moved out of their homes, at least briefly, and 28% had relocated permanently. In efforts to eliminate the infestation, 36% had destroyed home furnishings (including replacing the carpet); several of these specifically mentioned burning the offending items to prevent reinfestation.

Only 32% of those surveyed had not called in a pest control company. Of the 68% who had, 60% had their homes treated, but in 40% of the cases the PCOs refused to treat because no pest was identified. Additionally, 80% had treated their homes themselves, with 25% of those specifically mentioning "**Raid®**" as the product of choice. Other compounds listed included borax, Rid®, pyrethrins, Dursban® and Demon®.

The source of the infestation was identified as pets or wild/feral animals in 40% of the cases. Other potential sources mentioned included a yak hair **wig** and a **masseuse**. In attempts to eliminate the infestation, sufferers got rid of their pets (20%), beds and other furnishings (36%), and plants (12%). Other treatments mentioned were boiling clothing (36%) and daily washing and replacement of bed linens (28%).

Most commonly cited body treatments included digging parasites out of the skin (28%), treating the body with cortisone, Eurax® (crotarniton), Rid®, lindane or bleach (16% each), calamine lotion, insect repellent, or **pyrethrins** (12% each), or cooking oil, hot water, garlic water, melaleuca water, spearmint, peroxide, alcohol, iodine, vinegar, Pine Sol®, Lysol®, or applying Zostrix® (capsaicin), tetracycline, Neosporin® (polymixin B, bacitracin and neomycin), aloe vera, diatomaceous earth, insecticides (unspecified), lice **shampoo**, or gasoline. Other self-prescribed therapies included pulling out hair/eyebrows.

### Causes of "Delusory Parasitosis"

There are hundreds of potential explanations for symptoms mimicking the sensation of insects crawling in or on the **skin**, biting, or stinging. The term "delusory parasitosis" indicates a misattribution of very **real** symptoms to insects or mites, when the cause is something else altogether. Blum and Katz (1990) provide an excellent overview of some of these alternative causes. Possible explanations of the sensations include physical, physiological, and psychological causations.

Physical causes include static electricity, dry skin, irritants (chemicals such as some insecticides or mechanical such as fiberglass filaments/strands), etc.

**Everyone** experiences itching periodically throughout the day. Deflection of a hair, **drying** skin, rubbing against rough fibers--all can produce itching. Typically we rub or scratch briefly and absentmindedly, without noticing, because we have other things to occupy our attention. For people who live alone and have no distractions, once their attention is fixed on an itch, it grows to occupy all their attention. This experience is like lying awake, unable to sleep in the middle of the night; inevitably the mind will latch onto a single thought and worry it to death. This is similar to the phenomenon DP patients experience, sucked down into a vortex of fixation on the perceived irritation.

Physiological causes can range from allergies, through nutritional deficiencies and other diseases, to drug reactions. Allergies can include inhalant allergies, ingestant reactions, and contact **dermatitis**. Nutritional deficiencies producing pruritus or urticaria include vitamins, minerals, and other trace nutrients. Conversely, megadoses of many nutrients can produce itching, hives, and other skin sensations.

Psychological manifestations can result from such conditions as depression (Gupta et al. 1994) and stress (Gefler and Knoll 1990). Other symptoms such as tiredness, anxiety and tension are frequently associated with itching and tingling, indicating **that** they may share the same basic origins of stress. During high-pressure life events, adrenaline causes reactions within the body, and one way this stress is evidenced is by skin reactions, including prickling, stinging, and itching. People have no problem believing that stress can induce headaches, high blood pressure, acne, heart attacks and ulcers; so why is it so difficult to **realize that** stress can result in skin sensations such as itching, paresthesia, or "bites." These conditions are not in one's **head**; they are physiological responses to changes in body chemistry.

While people of all ages experience delusory parasitosis, victims are disproportionately the elderly. This is probably due to several factors. Older people typically have more medical conditions **that** may produce paresthesia, urticaria and pruritus. Older people take more medications, increasing probability that side-effects will develop or drug interactions will occur. Older people typically have more sensitive skin. Older people, especially those who live alone and have no outside interests, tend to focus on their symptoms, thereby magnifying and enlarging importance and significance of sensations.

Social isolation is one predisposing feature of **delusory** parasitosis situations. Some **delusory** parasitosis cases are just lonely people who need interaction with another human being. Elderly people who live alone, seldom get out, seldom have visitors, and have no purpose in life are prone to fixating on themselves and their health. Neglected elderly use complaints about "invisible bugs" to procure attention and sympathy. Thus, DP may be considered a derived form of Munchausen syndrome in which the patient perpetuates the sensations/complaints to evince additional concern (Merck Manual 1992).



Medications commonly prescribed for the elderly such as estrogens, beta blockers (for cardiac conditions), drugs for hypothyroidism, insulin--all these have been shown to produce symptoms such as urticaria, pruritus, paresthesia, etc. Of the 20 medications most commonly prescribed for the elderly, at least one of the following side effects--urticaria, pruritus, or paresthesia--was listed for each, and many had two or all three included. Antibiotics (e.g. amoxicillin, penicillin), estrogens (premarin), thyroid medications (e.g. Synthroid), treatments for prostatic hyperplasia (Hytrin), antidepressants (e.g. Prozac, Zoloft), angina drugs (e.g. Norvasc, Nitrostat), ulcer drugs (e.g. Prilosec, Zantac), cardiovascular drugs (e.g. Vasotec, Zocor, Pravachol), antihypertensives (e.g. Procardia, Cardizem), and analgesics (e.g. ibuprofen, acetaminophen, codeine, Darvon) are among the most commonly prescribed medications for people over 65, and all of these list either pruritus, urticaria, or paresthesia among observed side effects (American Druggist 1998).

Several factors contribute to the predisposition of older people experiencing adverse drug effects: they take multiple medications simultaneously (prescription and over-the-counter), the elderly frequently receive prescriptions from more than one doctor, drug **pharmacokinetics** vary by age, and seniors more frequently are confused by instructions or forget how often they have medicated themselves. While **over-65s** represent only 12 percent of the population, they receive over 30 percent of all prescription drugs (Jones 1997). Both psychologists and **dermatologists** have noted that organic causes must be excluded before a diagnosis of psychogenic pruritus can be pronounced (Gupta 1995).

Over **half** the drugs in use, both over-the-counter and prescription, list itching, hives, urticaria, pruritus, or some similar side effects (pruritus, hives, urticaria, burning, stinging, paresthesia, tingling, pins and needles). Cocaine and other "recreational" drugs are highly prone to producing sensations of "bugs" crawling on the skin. This aspect of popwar culture was featured in an episode of "The X Files" as "Elpern's Syndrome" (Elpern 1988), in which victims attempted to dig insects out of their skin ("War of the Coprophages").

Medical literature from the past five years shows over a hundred different causes of itching including infection with bacteria, fungi, viruses, nematodes, and various other pathogens and parasites. Some medical conditions producing these symptoms include diabetes, rheumatoid arthritis, hepatitis, carbon monoxide poisoning, cirrhosis, anemia, hypoglycemia, and hypothyroidism. Interestingly, the treatments for many of these conditions can also produce dysesthesias. Among these are insulin, anti-inflammatory drugs, and thyroid medications.

By prescribing scabicides such as Kwell (lindane), physicians validate the patient's conviction that the condition is caused by arthropods. However, most medical doctors do not perform diagnostic tests in establishing a differential diagnosis of scabies. These physicians who prescribe Kwell for non-existent infestations are likely the same M.D.s who prescribe antibiotics for viral infections such as the common cold.

Physicians claim they can determine the arthropod cause from the visible signs; the medical actuality is **that** physical responses to arthropod stimuli vary due to individual physiologies, such as immediate and delayed hypersensitivity reactions. The bite reaction is not unique for an arthropod group and does not allow an assumption regarding species diagnosis. The clinical manifestation of a bite reaction is dependent on the immunological situation of the host. Similarly, lesions displayed as evidence of infestation are indicative of scratching, not of the stimulus that provoked the scratching. Self-excoriation merely demonstrates that the person has been scratching; it gives no clue as to the causation.

#### Descriptions of Specimens

Once the sore begins oozing **fluid**, and scabs form, hairs and cloth fibers become entrapped in the sticky fluid. These flecks are dislodged and called mites or insects because they look like they have "antennae" and "legs." Often **hair** follicles are pulled out; the follicle accompanied by the associated sebaceous gland looks like a worm. Sometimes people claim they see the "creatures" jump. This is likely due to static electricity or magnetic charges of tiny particles. Some people view dust and other motes floating in a shaft of sunlight and claim they are tiny flying creatures.

People are able to describe in vivid detail the various life stages. Typically larvae enter the body through an orifice--ears, nose, or mouth. People can feel them moving under their skin. Eventually they metamorphose and emerge through the skin. Victims typically *dig* into their skin to extract this form, producing open wounds and scabs.

Interestingly, while these are invisible bugs, the sufferers can often describe their appearance, including colors and the presence of wings and legs. As already mentioned, these people are also often quite conversant about the life cycle of their particular affliction. Frequently these creatures change colors and go through dramatic metamorphoses. One of the most commonly described **shapes** is semi-circular (or half moon), like the end of a fingernail.

Almost inevitably DP sufferers will attempt to eliminate the "infestation" by treating their skin with some harsh **material** such as detergent, bleach, **ammonia**, vinegar, Pine Sol, Lysol, kerosene, alcohol, gasoline, insecticides, etc. Obviously when the body is assaulted with these caustic, **harsh** chemicals, the skin becomes dry and irritated, exaggerating the impression **that** there is an infestation. Even treatment with lotions and creams **may** exacerbate the condition, particularly once the skin is irritated and inflamed. Some treatments seem to produce short-term remissions, but invariably the pests resurge; this is typically blamed on hatching of eggs that were not susceptible to the treatment.

Not infrequently other members of the household or workplace begin to **participate** in the delusion. Not surprisingly, constant exposure to descriptions of symptoms causes other people to recognize similar sensations affecting them as well. As mentioned earlier, we all experience itching periodically. Once the mind is focused on the sensation, it is virtually impossible to avoid thinking about it. The power of suggestion is strong. When one person in a room yawns, the whole group yawns. Crowd psychology can probably explain the vast **majority** of these situations; once you **have** been told not to think about elephants, the only image in your mind is grey pachyderms.

Static electricity builds up in our bodies and attracts particles from the air. This phenomenon can be particularly evident for individuals working around electronic **equipment**, such as video terminals, as can be demonstrated by wiping a TV screen with a white cloth and viewing the adherent debris. Particularly in areas where there are lots of particles (plastic shards as from stripped insulated wires, fiberglass fibers, paper fragments from perforated forms) to impinge on the body, this **may** be perceived as "stinging insects."

Various environmental factors can produce prickling, tingling, or creeping sensations. Typical culprits include detached carpet fibers, paper particles, static electricity, contaminated ventilation systems, and indoor pollutants, such as new furnishings emitting volatiles (Jaakkola et al. 1994). In office situations there are frequent cases where all the workers in an area are exposed to whatever causes the irritation--as fiberglass insulation fibers being blown through heating ducts. Any work in the ceiling area which dislodges particles may subject people in the area to irritation from the particles.

Delusory parasitosis is not an entomological problem--it's a medical problem (either physical, physiological or psychological). The function of the entomologist is to determine whether an arthropod is involved. The area of concern should be identified (where are people being attacked, not just where they are responding) and surveyed (using sticky traps, vacuum, light traps, tape, etc.) to determine if arthropods are involved, and if so, what they are (Waldron 1962).

Sticky tape samples can be taken by the sufferer. These samples should be more meaningful because they represent the actual area of concern--the individual's body. **If** there is an organism involved, it should be captured at the instant when it is attacking. People typically enthusiastically participate in this aspect, providing dozens of tape strips taken at the moment the sensation is experienced. **If** there is an organism causing the sensation, this method should find them.

In conclusion, the entomologist's primary function is to determine if there is arthropod involvement. Investigation should focus on possible insect and mite problems. Urticating hairs from dermestids are a typical sanitation problem. Bird mites (*Ornithonyssus sylviarum*, *Ornithonyssus bursa*) and rodent mites (*Ornithonyssus bacoti*) may be present on vertebrate pests such as pigeons nesting on window ledges or rodents infesting the attic, necessitating vertebrate pest suppression to alleviate arthropod infestations. Once arthropods have been eliminated as the

probable cause, the individual should be encouraged to pursue investigation of possible medical causes, including the very real possibility of physiological causes, such as drug interactions or disease.

Clinical tests have demonstrated that anxiolytic medications, such as pimozide, frequently diminish delusory parasitosis symptoms sufficiently to break the **cycle**. Letters reporting the entomologist's conclusions following examination of specimens thus may contain suggestions such as, "The symptoms you are experiencing are very real and deserve further **examination**. To help reduce your suffering while we search for the root cause, you might discuss with your physician the possibility of his prescribing a medication like pimozide to help alleviate your discomfort while we continue to investigate possible causes." This simultaneously demonstrates concern for the individual, encourages their pursuing medical interventions, and alerts the physician that the entomologist suspects potential psychological involvement.

#### Questions on DP Questionnaire

What made you first suspect that the problem is due to insects or mites? How many people are being affected and what are their symptoms? Describe the pests, their color, shape, size. Do they walk, crawl, fly, hop ... ? Do they change form? Can you describe their life **cycle**? Where do they come from? Where did they originate? When? What initiated the problem? Where they found in the home? On your body? At what times of day are they most active? What do the bites look like? Where are they located? What do they feel like? What have you treated with? In the house? (name products including cleaning agents, insecticides, etc.) On your body? Have you had pest control operators or exterminators treat your home or outside? What product did they use? What other techniques have you tried? Washing the bedclothes? Vacuuming? Mopping? Moving out of the house? Have you seen a doctor? What did he or she say? What medications have you **taken** in the past year? What are you allergic to?

Mail completed form with specimens (on clear tape or in alcohol) to Dr. N.C. Hinkle, Dept. Entomology, UCR, Riverside CA 92521

#### Sample Letter

Mrs. Tru Sufferer  
Invisible Bug Lane  
Any City CA

Dear Mrs. Sufferer:

I have examined all of the samples you provided and found that virtually all of the items were pieces of lint, plant fragments, skin scales, scabs and other skin products, and miscellaneous bits of inorganic debris. There were no insects or other arthropods. There was nothing in the materials submitted that suggests any living organism that either bites or penetrates human skin.

This information is no doubt disappointing to you in that it does not help pinpoint any specific cause of your problem. At the same time, be aware that any of the materials used to treat either the home or yourself may be exacerbating the **situation**. Even "natural products" can be harsh and potentially sensitizing.

There are dozens of potential causes of your symptomatology, and I encourage you to investigate those other than arthropods as we have found no evidence of their involvement. You might also contact the "BUGS" hotline at (900) 225-BUGS. While this is a toll call, the specialists there have experience with these situations and may be able to offer suggestions.

The symptoms you are experiencing are very real and deserve further **examination**. To help reduce your suffering while we search for the root cause, you might discuss with your physician the possibility of his prescribing a medication like pimozide to help alleviate your discomfort while we continue to investigate possible causes.

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SOUTH CAROLINA MASTER TERMITE TECHNICIAN TRAINING: LINKING EXTENSION  
EDUCATION AND PESTICIDE REGULATION TO MEET STATE COMPLIANCE  
STANDARDS FOR SUBTERRANEAN TERMITE TREATMENTS.

Eric P. Benson<sup>1</sup>, Neil I. Ogg<sup>2</sup>, James Wright<sup>2</sup> and Elizabeth M. Kane<sup>2</sup>

<sup>1</sup>Department of Entomology, Clemson University  
113 Long Hall, Clemson, SC 29634

<sup>2</sup>Department of Pesticide Regulation, Clemson University  
511 Westinghouse Road, Pendleton, SC 29634

The South Carolina Master Tennite Technician (MTT) School was established in 1990. The South Carolina Pest Control Association and Clemson University are the **main** sponsors of the school. Training is held approximately twice each year at the Clemson University Sandhill Research and Education Center, centrally located in Columbia, South Carolina. The two day program involves classroom sessions and practical training at a custom built foundation **that** includes a variety of building techniques common in South Carolina. To graduate as a Master Tennite Technician, participants must pass a written exam and a series of practical tests. School organization, instruction and testing of MTT participants is provided by members of the Clemson University Department of Pesticide Regulation and Extension faculty in the Department of Entomology.

The MTT school has two primary goals. The first goal is to enhance the knowledge and treatment skills of South Carolina technicians involved with tennite control. The second goal is to improve tennite treatments for state residents by increasing the compliance of pest control companies to state regulatory tennite treatment standards. In 1995, a survey was conducted of 195 randomly selected MTT graduates to determine how attending the school affected their practices. Of the 52 respondents, 98% reported better understanding of South Carolina tennite treatment standards.

Since its inception, the **MTT** program has changed to incorporate new research-based information and new tennite control methods such as foaming techniques, in-line injection equipment and tennite baiting systems. Special **MTT** programs also were developed for South Carolina County Agents to **enhance** their ability to understand and inform the public on proper termite treatment methods. The link between Extension education and Pesticide Regulation has been a dynamic and effective alliance in helping to provide quality termite treatments for the residents of South Carolina.

Key Words: termites, control, education, regulation

## THE ROLE OF THE NATIONAL PEST CONTROL ASSOCIATION IN FIELD TECHNICAL ASSISTANCE

Greg Baumann, Director of Field Services  
National Pest Control Association  
8100 Oak St., Dunn Loring, VA 22027

### Introduction

The National Pest Control Association has since its inception in 1933 been a leader of the pest control industry. Early in the life of NPCA, leadership decided that a strong technical staff was vital to provide pest control operators assistance in the field with their daily technical challenges.

### Publications

The role of NPCA in the area of technical services is multi-faceted. NPCA produces technical aids for the pest control operator. These include the NPCA Pest Management Library, a compilation of technical and business information necessary to run a pest control firm or to perform pest control activities. The Library is updated monthly through Library Updates covering technical and business issues. A second volume of the Library, The Wood Destroying Organism Volume, was introduced in 1998 and includes some of the Approved Reference Procedures sections which has become a cornerstone of the industry. The NPCA Resource Center provides educational materials available for all pest control operations. Recently, pest control operators from foreign countries have discovered the value of the Resource Center. In 1997, NPCA and ASPCRO released the combination video and workbook for new service technicians.

### Daily Operations

In April, 1996, new leadership at NPCA recognized the need for pest control operators to be able to contact NPCA for individual assistance. NPCA historically had performed similar services but had not communicated the service as a cornerstone of NPCA. In 1996, a field Services Department was created and includes a chemist and an entomologist, both with field experience. In 1996, membership in NPCA increased from 1800 member companies to about 4,600 member companies through the Joint Membership program. These members can call in and discuss their questions, either technical or business, with NPCA staff. Currently, the department fields up to 100 calls daily.

NPCA, as a nonprofit, has created the structural pest control industry's website, Pestworld. The site contains business, technical, and legal information. The site is divided into general access and a restricted area for members only. The restricted area includes valuable information for members such as all technical releases and Library Updates since May 1, a search engine, excerpts from the NPCA *Field Guide to Structural Pests*, online registration for events such as conventions. NPCA has successfully hosted monthly scheduled chats online with industry experts on legal, public relations, and technical issues.

The website is receiving approximately 4,000 hits per day. Homeowners, media, and pest control operators alike are finding the information that they need on the website. It has also generated significant name recognition for NPCA.

### Why NPCA?

Many states have excellent resources within the state to provide technical assistance for the pest control operator; however, pest control operators utilize the NPCA services primarily because the NPCA is *their* organization. Further, NPCA brings a national perspective and in some cases, an *international* perspective. Pooling experience and resources provide a detailed base for assistance to the pest control operator. Also, extension assistance in some areas has been reduced due to budget constraints. We always encourage pest control operators to check with extension professionals where available; however, NPCA fulfills a need that more than justifies the pest control operator's membership in NPCA.

**PROBLEMS IN SUBTERRANEAN TERMITE TECHNOLOGY TRANSFER,  
COMMERICAL SPEECH, AND CONTROL PRACTICES**

Bill J. Hawks, Jr.  
Bionergics  
P.O. Box 412  
Wichita, KS 67201

Abstract not available... ..

# A SUMMARY OF RECRUIT® AG TRIALS AND STATION PLACEMENT IN CONJUNCTION WITH ACOUSTIC EMISSION COUNTS IN THE NORTHEASTERN U. S.

George Rambo, George Rambo Consulting Services, Herndon, VA  
and  
James D. Thomas, Dow AgroSciences, Bel Air, MD

Trials were conducted using two styles of prototype **Recruit®** AG bait stations, containing 0.5% hexaflumuron on a cellulosic matrix; as a method of delivering bait to above ground infestations of subterranean tennites. The soft style station contained 15 g. bait matrix in a flexible plastic pouch. The hard-style station contained 25 g. of matrix in a rigid plastic box. Stations of each type could be stacked so that additional bait could be placed on an active feeding site without disturbing the termites. Station placement was made based on visual inspection, and augmented by monitoring for tennite feeding activity using an acoustic emission detection device (AED). Tests were conducted at 10 sites in New York, Pennsylvania, **Maryland**, and Virginia.

The mean number of station placements at each test building, including both station types, was 6.6 (2.7 hard and 3.9 soft style). Tennites fed on bait matrix at 65% of bait placements, including 74% of hard style and 59% of soft-style placements. A mean of 15 total stations (5.5 hard style and 9.5 soft style) were used at each test building, and total bait consumption averaged 178 g (sd = 167) prior to elimination of termite activity. Mean time to termite elimination, including multiple colonies in some cases, was 264 days (sd = 110) with a range of 110-385 days. The most common substrate for attachment of bait stations was wood (70%), followed by brick or concrete (24%), and drywall or other substrates (6%). Bait consumption occurred on 54% of placements on wood and 94% of placements on brick or concrete. On infested wood, 56% of placements were fed on, and 76% of placements made over an active tube had feeding.

The number of AED counts appeared to be a good indicator of the likelihood of termite feeding. When counts ranged from 0-50 per minute, tennites fed on 26% of placements within two months. When counts were >50, tennites fed on 82% of placements within two months. In several cases, no live tennites could be located without the aid of the AED. AED counts also declined as termite activity declined, providing supporting evidence of tennite elimination.

These trials confirmed the utility of **Recruit** AG for tennite elimination. No difference was noted in performance between **hard** and soft style stations. Based on these and other results from Experimental Use Permit trials across the U.S., a hard style **Recruit** AG station has been commercialized and is now a component of the **Sentricon® Termite Colony Elimination System**. The apparent relation between AED counts and tennite feeding suggests use of an acoustic emission detector can be a valuable tool for use in conjunction with **Recruit** AG.

Key Words: **Recruit®** AG, *Reticulitermes* spp., hexaflumuron, **Sentricon® Termite Colony Elimination System**

\*Trademark of Dow AgroSciences LLC

PHYLOGENETIC DIVERSITY AND GEOGRAPHIC STRUCTURE IN SYMPATRIC  
SPECIES OF *RETICULITERMES* (ISOPTERA: RHINOTERMITIDAE):  
A MATERNAL PERSPECTIVE.

Tracie M. Jenkins and Brian T. Forschler  
Department of Entomology, University of Georgia  
Athens, GA 30602

Despite the economic importance of subterranean termites in the United States their intraspecific population structure is poorly understood. We conducted the first extensive population genetics study of sympatric *Reticulitermes* species populations in which maternal gene flow across a varied **geographical** region was examined. Seventy-eight individual tennites were sampled from 21 established termite monitoring sites across four soil provinces in Georgia.

Amplified mitochondrial DNA (mtDNA) fragments were sequenced from each individual. Sequence comparisons showed species-specific tandemly unique sites which opens the possibility of using nucleotide sites from amplified mtDNA as **markers** to distinguish between *Reticulitermes* species. Although differences were recorded at the colony level these differences are only applicable to distinguishing maternal lineage not colony associations. Termite sequences also were analyzed by both cladistic and phenetic methods. Phylogenetic analyses separated species and demonstrated low levels of molecular divergence among *R. jlavipes*, making resolution of lineage's difficult.

*Reticulitermes jlavipes* and *R. virginicus* also were significantly different **genetically** according to the Hudson, Boos, and Kaplan statistic, but *R. jlavipes* geographic populations were not. Assumptions of intraspecific relatedness, therefore, cannot be based on geographic locations in Georgia. This information is contrary to current concepts concerning gene dispersion within subterranean termite populations which have long been considered inbred and/or closely related within a given area. The long distance dispersion indicated by these data cannot be explained by the **weak** flyer hypothesis of subterranean termite alate biology.

USING GENETIC MARKERS TO DISTINGUISH AUSTRALIAN *COPTOTERMES ACINACIFORMIS*  
(FROGGATT) (ISOPTERA: RHINOTERMITIDAE)

Jiasi Wang\* and J. Kenneth Grace  
Department of Entomology University of Hawaii at Manoa

Abstract

Twenty-five colonies of *Coptotermes acinaciformis* that have two different nesting behaviors, subterranean and mound-building, were collected from around Australia. Polyacrylamide vertical gel electrophoresis was used to analyze allozyme variation among the two groups of *C. acinaciformis* with different nesting behaviors. Six esterase loci were identified in the samples of *C. acinaciformis*. Est-1, Est-3, Est-4 and Est-5 were found in both subterranean and mound-building colonies, while Est-2A was only found in subterranean colonies, and Est-213 only found in mound-building colonies. Est-2A and Est-213, as well as Est-4 and Est-5 were polymorphic. Est-5 was polymorphic in subterranean termites, but was fixed at F allele in the mound-building termites. Also we discovered no significant genetic differences in mound-building termite groups inhabiting different geographical areas, but there was significant genetic diversity indicating that the mound-building groups were one population while the subterranean groups consisted of two or more populations. In conclusion, the data obtained from current samples showed that groups of *C. acinaciformis* with different **nesting** behaviors **differ** genetically.

# CHARACTERIZATION OF CYTOCHROME P450 MONOOXYGENASES IN THE DARK SOUTHERN SUBTERRANEAN TERMITE, *RETICULITERMES VIRGINICUS*

Steven M. Valles,<sup>1</sup> Weste Osbrink,<sup>1</sup> Faith M. Oi,<sup>2</sup>  
Richard J. Brenner,<sup>1</sup> and Janine E. Powell<sup>3</sup>

1USDA-ARS, Center for Medical, Agricultural and **Veterinary** Entomology,  
Gainesville, Florida 32608

2Department of Entomology, Auburn University,  
208 Extension Hall, Auburn University, Alabama 36849

3USDA Forest Service, P.O. Box 928,  
201 Lincoln **Green**, Starkville, Mississippi 39759.

Although insecticides have been used for decades against subterranean termites, very little is known about their detoxication enzyme systems. However, recent introduction of the Formosan subterranean tennite into the United States, EPA withdrawal of organochlorine tennitocides and growing public concern have contributed to an urgent interest in understanding subterranean termite biology more thoroughly. We characterized microsomal oxidases in *Reticulitermes virginicus* workers and soldiers collected from seven locations in Florida and Alabama. Aldrin epoxidase activity required the cofactor **NADPH**, and was inhibited by **carbon** monoxide and piperonyl butoxide, a well-known cytochrome P450 monooxygenase inhibitor. These data indicate that aldrin epoxidation was catalyzed by a cytochrome P450 monooxygenase. Aldrin epoxidase activity was highest at 22° C and pH 7.2. Also, the activity was linear up to 0.5 mg protein per incubate and increased with reaction time up to 15 minutes. Inhibition of aldrin epoxidase activity occurred above 22° C indicating temperature sensitivity. While increased incubation temperature above 22°C resulted in decreased aldrin epoxidase activity, similar heat treatments did not result in a concomitant increase in cytochrome P420 (degraded cytochrome P450). Swprisingly, significant variation (3.7-fold) in aldrin epoxidase activity was observed among the seven *Reticulitermes virginicus* colonies collected from sites in Florida and Alabama. Whether these differences represent inherent variation among this species, stage-dependent or other developmental effects, or a direct response to environmental factors (i.e. enzyme induction) is not known.

## KEYWORDS

subterranean termite, *Rejiculifermes virginicus*, cytochrome P450, detoxication



LABORATORY EXAMINATION OF BIO-BLAST™ BIOLOGICAL TERMITICIDE  
AGAINST *RETICULITERMES* SPP. (ISOPTERA: RHINOTERMITIDAE)

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

Laboratory trials were conducted using two species of subterranean termites, *Reticulitermes flavipes* and *R. virginicus*, simulating label application of Bio-Blast™ Biological Termiticide. Three groups of each species (approximately 10,000 termites per group) containing secondary reproductives, eggs, larvae, workers, and soldiers were used in bioassay. Termites were maintained for at least 2 months prior to testing in a clear plastic box (31.5 X 25.6 X 9.8-cm; L:W:H) and provided with pine wood and moistened filter paper. This container was considered the nest chamber and each group was provided access to four additional feeding chambers consisting of plastic containers (15 cm dia. X 4-cm height) lined with 2-mm layer of moistened sand. Feeding chambers also were provided with 10 g of decayed, mixed pine/hardwood sawdust and one 4 X 14-cm X 1-mm (W:L:H) piece of pine wood. Each nest chamber was positioned in the center of the bioassay arena arrangement and connected to two feeding chambers by a 1-m length of 2-mm (id) tygon tubing. Two additional feeding chambers were connected to those feeding chambers by an additional 1 m length of tygon tubing. Therefore, bioassay arrangements consisted, from left to right, of two feeding chambers connected to the nest chamber followed by two additional feeding chambers. Termites had to travel through one chamber to enter the next chamber such that the two most distant feeding chambers were located 4m apart. Termites were allowed one week to acclimate and 'colonize' each feeding chamber at which time one of the end-most feeding chambers was randomly assigned as a treatment chamber. Those designated treatment chambers were treated with 8-mls of Bio-Blast™ Biological Termiticide solution applied according to label instructions using a hand-held, pump-action plant sprayer. Three to five hundred termites were present in each feeding chamber at the time of treatment. Termite activity in each chamber was recorded daily for one month at which time all arenas were dismantled and the number of termites counted.

Termite activity, following treatment, was lower in the treated chambers in all but one of 6 replicates. Two of the three *R. virginicus* groups provided significantly fewer termites at the end of the test. All three *R. flavipes* groups provided survivorship comparable to the control. These tests indicate the potential for whole colony effects using Bio-Blast™ Biological Termiticide, following treatment of 5-8% of the population, is low. Additional tests indicate that each treated termite is capable of harboring  $1-2 \times 10^5$  spores. This high fungal pathogen load should be capable of killing many termites. Yet, because of the lack of mortality we observed in our tests, there are probably antagonist interactions occurring within established groups of termites. These interactions, which could combine both chemical and behavioral defenses, should be considered in laboratory bioassay of fungal pathogen efficacy.

SURVIVAL OF VARYING DENSITIES OF TWO SPECIES OF UNFED SUBTERRANEAN TERMITES  
EXPOSED TO A FIXED NUMBER OF HEXAFLUMURON-FED  
COHORTS (ISOPTERA: RHINOTERMITIDAE)

Kristen G. van den Meiracker<sup>1</sup>, Patricia A. Zungoli<sup>1</sup>, Eric P. Benson<sup>1</sup>, and  
William C. Bridges, Jr.<sup>2</sup>

<sup>1</sup>Department of Entomology, Clemson University  
Clemson, SC 29634

<sup>2</sup>Department of Experimental Statistics, Clemson University  
Clemson, SC 29634

Three colonies each of *Reticulitermes flavipes* (Kollar) and *Coptotermes formosanus* Shiraki were used in this experiment. *R. flavipes* and *C. formosanus* colonies were **taken** from field sites or laboratory colonies, respectively, in Gulfport, MS. Groups of 20 worker termites (3rd\_5<sup>th</sup> instar) from each colony were allowed to feed for one week on a cellulose matrix impregnated with 0.5% hexaflumuron and Nile Blue (500 ppm). Blue termites were placed with groups of 20, 40, 200 or 400 cohorts starved for 24 hr. Termites were held in experimental units consisting of a plastic Petri dish (10 x 2 cm) and a smaller container (5.5 x 3.5 cm) soldered together. A moist sand/vermiculite mixture within the experimental unit provided termites a substrate in which to live. Both matrix and sand/vermiculite mixture were moistened *ad libitum* throughout the experiment. Termites were held at 25 °C. Two replicates per treatment group were used, with a total of 216 replicates. Control groups were fed untreated cellulose matrix impregnated with Nile Blue (500 ppm). Survivorship of both blue and white termites within each population density was assessed at 4, 6 and 8 wk. ANDVA was performed on the data with significant differences determined at  $p \leq 0.05$ . Least squares means were compared using LSD as means separation test.

No significant differences in mean percent survivorship between the four densities occurred after exposure to the hexaflumuron-fed cohorts for 4 wk; however, results after 6 wk exposure varied with ratio and species. Significantly lower survivorship occurred in all groups exposed to treated cohorts for any ratio at 8 wk. No significant differences in mean percent survivorship occurred between ratios of treated groups within each time period (4, 6 or 8 wk). No significant difference was detected in survivorship between species. Results indicate that limited exposure to a fixed number of hexaflumuron-fed termites results in a similar mortality level in all densities by 8 wk. Results also indicate that transference of hexaflumuron, whether through trophallaxis, coprophagy, grooming or cannibalism, took place early in the experiment to result in the significant drop in survivorship by 8 wk.

**Key Words:** Hexaflumuron, density, *Reticulitermes flavipes*, *Coptotermes formosanus*

## CHLORFENAPYR: A NEW INSECTICIDE FOR URBAN PEST MANAGEMENT.

B. L. Reid & R. A. Farlow  
Agricultural Products Research Division  
American Cyanamid Company  
Princeton, New Jersey 08543

### IntrOduction

Chlorfenapyr was discovered at Cyanamid's Agricultural Research Center in 1988. It is the first compound developed from a totally new insecticide class, the pyrroles.

Chlorfenapyr is a pro-insecticide with a novel mode-of-action that does not involve the nervous system. After exposure, mixed-function oxidase enzymes convert cWorfenapyr to an active form that uncouples oxidative phosphorylation by disrupting the electrochemical gradient across the mitochondrial cell wall. This vital metabolic process is inhibited and the insect dies from an inability to generate its own energy.

Chlorfenapyr is a broad spectrum insecticide, with good contact activity, roughly equal to organophosphates or carbarnates, and has excellent activity when ingested.

### Features & Benefits

Three years of research on urban insect pests has identified several features and benefits of chlorfenapyr. Its mode of action forms a basis for two benefits: chlorfenapyr causes delayed-action mortality and there is a lack of cross-resistance in important public health pests.

Residual deposits of cWorfenapyr on common surfaces, and residues in soil, are not repellent.

Lastly, due to its chemical and physical stability and low vapor pressure, cWorfenapyr will provide excellent residual control.

### PCO Products

Two formulations are available for testing: a suspension concentrate **that** contains 2 pounds of active ingredient per gallon, and a wettable powder, formulated at 25% active ingredient.

Based on acute toxicity studies, both formulations will **carry** a CAUTION signal word. Neither product is more than slightly irritating to the eye or **skin**, and chlorfenapyr is not a dermal sensitizer.

Based on *in vitro* and *in vivo* studies, cWorfenapyr is not oncogenic or carcinogenic, it is not a reproductive or developmental toxicant, and there are no estrogenic or endocrine effects.

### Pests & Use rates

Dilute spray preparations of 0.25% to 0.5% are recommended for crack and crevice and spot treatments to control cockroaches.

Dilute spray preparations of 0.1% to 0.25% are recommended for indoor and outdoor applications against ants, either as a residual treatment or a mound drench.

For subterranean termites, dilutions of 0.125% and 0.25% are being evaluated in field trials for post-construction treatments.

In the balance of this report, we overview results of laboratory studies and field trials supporting these recommendations.

### Contact toxicity in **German** cockroaches

Stainless steel panels were sprayed with diluted formulations of cWorfenapyr. Male German cockroaches were exposed to treated surfaces for just 1 hour before being transferred to clean jars for observation of mortality.

The delayed-action mortality of cWorfenapyr is evident, as mortality increased over the 4 days of observation (Fig. 1). The **25WP** formulation, specifically designed for crawling insects was more active than the **2SC** formulation.

### Knockdown activity in German cockroaches

In this study, cockroaches were acclimated in harborages and sprayed with dilutions of chlorfenapyr formulations at a rate of 1 gallon per 1,000 ft<sup>2</sup>

There was little or no difference between rates (Fig. 2) and, while both formulations caused significant mortality within 24 hours, the superiority of the 25WP formulation is evident.

### Residual control of German cockroaches

Methods identical to those in an earlier slide were used to evaluate residual life on treated surfaces. After 6 months there was no loss of activity for the 25WP **formulation**, and the 2SC retained between 80% and 90% of its initial activity (Fig. 3).

### Lack of **cross-resistance** in German cockroaches

Chlorfenapyr is not affected by **metabolic** detoxification mechanisms in German cockroaches. Technical active ingredient, diluted in acetone, was applied in 1 DI droplets to the ventral mesothorax of adult males; mortality assessed at 72 hr.

Compound	Strain	RR <sub>50</sub>	RR <sub>95</sub>
Chlorfenapyr	Muncie '86	0.8	1.5
	Munsyana	1.5	1.9
Chlorpyrifos	Muncie '86	10.6*	8.7*
	Munsyana	14.3*	12.2*
Cypennethrin	Muncie '86	4.2*	5.0*
	Munsyana	148.2*	291.8*

- - significantly less susceptible than Jwax-S strain

These field-collected strains possessed differential expression of oxidase, esterase and/or hydrolase mechanisms, and the moderate- to high-level resistance these mechanisms confer to chlorpyrifos and cypermethrin did not confer **cross-resistance** to **chlorfenapyr**.

### Efficacy, German cockroaches

Field trials in multifamily housing have confirmed the effectiveness of **chlorfenapyr** against the German cockroach.

This trial compared **chlorfenapyr** formulations with a tank-mix of cyfluthrin and chlorpyrifos (Fig. 4). Through 2 weeks, both rates of the chlorfenapyr WP formulation gave initial control comparable to the standard, and the WP formulation caused more rapid knockdown than the 2SC formulation. Overtime, the 0.5% dilution for either formulation was comparable to the standard.

This trial compared chlorfenapyr formulations with cypennethrin (Fig. 5). No differences between chlorfenapyr formulations were evident. Dilutions of 0.25% **chlorfenapyr** performed equivalently to cypennethrin, and 0.5% dilutions provided control numerically superior to cypennethrin.

### Contact toxicity in ants

Ants are increasingly important pests in residential, institutional and commercial environments.

Laboratory studies determined susceptibility to residues of **chlorfenapyr** in seven ant species: *Tapinoma sessile*, *Camponotus vicinus*, *Jyfonomorium pharaonis*, *Solenopsis xyloni*, *Messor pergandei*, *Liometopum* spp., and *Linepithema humile*. As there were no substantive differences among ant species, the data are averaged across all 7 species tested (Fig. 6).

Rates of 40 mg/m<sup>2</sup>, from 0.1 % dilutions applied at 1 gallon per 1000 ft<sup>2</sup>, caused high levels of mortality within 6 to 24 hours of exposure. Interestingly, the 2SC formulation of chlorfenapyr is inherently more active.

### Efficacy against ants

Field trials show chlorfenapyr to effectively control structure-infesting ants. In all of these trials, populations were monitored at multiple locations around the infested structure, and dilutions were broadcast to the building's perimeter.

This trial against Argentine ants compared two rates of the 2SC formulation, applied at 1 gallon per 100 ft<sup>2</sup> (Fig. 7). Both rates caused rapid reductions in ant populations. The 0.25% dilution maintained near 80% control through more than 8 weeks, while the 0.1 % dilution broke at 4 weeks.

This trial against Argentine ants compared the 2SC and 25WP formulations at a 0.25% dilution, applied at 1 gallon per 170 ft<sup>2</sup> (Fig. 8). Relative to the untreated check, both formulations controlled the ants throughout the 8 week study.

This trial against ghost ants compared the 2SC and 25WP formulations at a 0.25% dilution, applied at 1 gallon per 40 ft<sup>2</sup> (Fig. 9). Relative to the untreated check, both formulations controlled the ants throughout the 8 week study.

Trials in 1998 will **examine** control in other ant species, and continue to define the relationship between dilution rates, application volumes and residual control.

#### Potential as a termiticide

Control of subterranean termites by soil treatment is another use where chlorfenapyr has demonstrated effectiveness.

Delayed-action mortality, and a lack of repellency to chlorfenapyr residues in soil, combine to create a zone of treated soil that kills foraging termites. The chemical stability and residual activity of chlorfenapyr will also be **important** to its potential as a termiticide.

#### Contact toxicity, subterranean termites

Concentrations of chlorfenapyr were tested in a sandy loam soil. Using standard methods, termites were confined in a petri dish (5 cm ill), and were observed at 8-hours and again at 24-hours.

There were no toxic effects after 8 hours of exposure [this was true for all rates tested, through 1,000 ppm]. At 24 hours moribundity was noted only at rates of 100 ppm or higher (Fig. 10).

Normally, this test would be terminated at 24 hours, however, due to a delayed-action mortality attributable to chlorfenapyr's mode-of-action, all live **termites** were transferred to untreated soil and observed through 7 days.

Moribundity increased over the next 6 days and, in the final analysis, concentrations of chlorfenapyr as low as 25 ppm caused 100% mortality.

#### Tunneling bioassays

Using classic methods, this study measured termite penetration into and through soils treated with chlorfenapyr. Soil containing residues of 1 to 100 ppm of chlorfenapyr were not repellent, as termites rapidly tunneled into and frequently penetrated the 5-cm of treated soil (Fig. 11). In contrast, there was virtually no penetration of the repellent, permethrin residues.

Because exposure to chlorfenapyr is lethal, high levels of mortality was realized after 6 days. In contrast, there was virtually no mortality in termites exposed to repellent permethrin residues.

#### Contact toxicity, soil types

Soil type has a profound effect on bioavailability of termiticides. Soils from across the country, from a heavy Mississippi clay to a light Florida sand, were treated at just 25 ppm chlorfenapyr. In a forced exposure, we see slight impacts of soil type at 3 days - when chlorfenapyr's delayed-action would be **peaking** - and by 5 days 100% mortality was achieved in all soil types (Fig. 12).

Due to a lack of repellency and delayed-action, termite interactions with chlorfenapyr treated soil are maximized, greatly reducing the impact soil types have on termiticidal activity.

#### Efficacy, subterranean termites

The 2SC formulation of chlorfenapyr entered the national field trials of the USDA Forest **Service** in 1996. First year data found that all rates, down to 0.125%, were intact in the modified ground board (slab) tests at all four locations.

Since late 1996, American Cyanamid has conducted field trials of post-construction efficacy with the 2SC formulation of chlorfenapyr. In these trials, which include the genera *Reticulitermes*, *Heterotermes*, and *Coptotermes*, chlorfenapyr has stopped all termite foraging **through** soil treated at rates as low as 0.125%.

The EPA has approved a two-year Experimental Use **Permit** to evaluate soil treatment with chlorfenapyr for **termite** control. During this EUP program, rates of 0.25% and 0.125% will be evaluated for their ability to control of active, structural infestations of subterranean **termites**.

### **Registrations**

Petitions have been submitted to the EPA seeking approval for indoor, non-food and outdoor uses of chlorfenapyr. Studies are underway to obtain approval for use in food-handling establishments. Approval for chlorfenapyr 2SC in termite control is pending acceptable residual efficacy data.

**CONTROL OF STRUCTURAL INFESTATION OF *HETEROTERMES AUREUS*  
IN ARIZONA WITH SENTRYCON COLONY ELIMINATION SYSTEM**

Thomas H. Atkinson, Michelle M. Smith, and Robert E. Williams  
Dow AgroScience  
Indianapolis, IN 46268

Abstract not available .

SYSTEMATIC TERMITE CONTROLsM...RESULTS IN THE REAL WORLD  
THE ORKIN® EXPERIENCE IN FLORIDA

Richard Lewis, James Ballard, and Gary Cramer,  
FMC Specialty Products

ABSTRACT

A national service firm has used the Systematic Termite Control approach to control termites around structures in Florida. In 1996, the firm used Sentricon™ termite bait at approximately 1000 structures while in 1997, the firm used FirstLine™ termite bait at approximately 1500 structures. Control levels were similar for each of the baits used during the first year of service. Additional details will be provided.

PAPER

In 1996, Orkin® Pest Control branch offices located in Florida, installed the Sentricon™ Colony Elimination System at approximately 970 properties. Although the use of termiticide is not recommended when using the Sentricon system, the scope of service that was used by Orkin was:

Treat wall voids with dry foam termiticide.  
Install Sentricon stations, monitor and bait as directed.

In 1997, Orkin embraced a program from FMC called Systematic Termite Control<sup>sm</sup> (STC), which is an IPM type program containing the following 6 elements: Inspection, Moisture Management, Food Source Management, Termiticides, Termiticide Foam, and Termite Baits. Following the STC program, Orkin branches in Florida installed monitors and or FirstLine™ GT Termite Bait stations at approximately 1000 properties.

The scope of service that Orkin used on the 1000 FirstLine properties was:

Treat wall voids with dry foam termiticide.  
Spot treat soil for 10 feet on either side of any areas with active termites using a termiticide emulsion.  
Install monitor stations or FirstLine GT baits.

In addition, approximately 960 properties, where Sentricon had been installed in 1996, were converted to FirstLine in 1997.

The methodology for the installation of the monitors and the FirstLine baits was as follows:

Inspect the structure.  
Identify conditions conducive to subterranean termite infestation.  
Install a monitor at each point of a twelve inch triangle in each conducive condition area around the structure which did not contain live termites.  
Install a FirstLine GT bait at each point of a twelve inch triangle in each conducive condition area containing live termites.  
All stations were monitored on a monthly basis and infested monitors were baited by installing a pair of FirstLine GT bait stations within two inches of the infested monitor.

To determine how well each of the termite control strategies was working, records from a single Orkin branch in Florida (Branch A) were manually searched and the information summarized. All structures were pretreated and most were either completely or partially treated with liquid termiticide prior to any involvement with bait programs.

Branch A installed Sentricon at 240 properties over a 15 month period beginning in 1996. A search of records from 50% of the properties indicated that after one year:



21 % required additional liquid treatment within the first year because of swarming or termite activity.

Branch A also installed FirstLine at 156 properties over a 15 month period beginning in 1997. A search of these records indicated that:

26% required additional liquid treatment within the first year because of swarming or termite activity.

No significant difference between the performance of the two technologies was noted.

In looking more closely at station performance, the February and March installations of Sentricon in 1996 were compared to the February and March installations of FirstLine in 1997. Monitors were installed in February or March and the structures were then monitored for the remainder of the year. Control was defined as the absence of termite activity for at least 3 months following bait consumption.

1997	FirstLine	1996 Sentricon
# Properties	74	74
# Properties with Monitor Hit	68	70
# Properties with Control for 3 Months	8	10

Again, not much difference between the performance of the two technologies was noted.

Focusing upon the performance of FirstLine GT stations, 137 properties were monitored and or baited throughout 1997 by Branch A. The results through December 1997 are depicted.

Properties	Mean # Zones Per Property	% Properties with Monitors Hit	Mean Days To a Hit	% Properties with Control	Mean Days To Control
93 active	12	88	87	29	72
44 preventative	12	66	112	30	43

Twelve zones of 3 stations each were used at each property. Note that the 93 properties with active termites required about 3 months to get a hit on a monitor and another 3 months for control to be achieved. Additional time will be required to obtain control at the remaining properties. Properties that were preventative, had less activity, took longer to get hits but control was achieved in less time. These data probably reflect the termite pressure and the size of termite populations surrounding active vs preventative situations around structures.

Seasonal reduction in termite activity is well known in the literature and has a significant impact upon the ability of a baiting program to get control in the first year of a control program. If properties have monitors installed in the first quarter of the year, and most of the properties get hits in the second quarter, then baits are installed in the third quarter but then termite activity slows down in the 4th quarter of the year. This seasonal interference may be reflected by callbacks which occur within the first year of the control program.

A review of several branches outside of Florida, where monitors and or FirstLine baits were installed late in the season at multiple year callback properties, revealed that termite pressure and population size probably play an important role in getting control at these properties.

Branch State		Zones	Properties	% Properties With Monitors Hit
B	OH	8	9	78
C	DE	6	11	45
D	GA	12	38	95

These sites had been active for **many** years and were provided monitors in early 1997. Most structures have monitors infested with tennites and are just entering the baiting **phase** of the control program.

A large number of variables influence the control of subterranean tennite populations in and around structures. Important variables which influence the control of tennite populations on properties would include:

- Geographic location within the US.
- Local climatic conditions.
- Number of subterranean tennite species in geography.
- Time of year.
- Active vs preventative control program.
- Number and location of conducive conditions and resulting monitoring and baiting zones.
- Diligence to monitoring schedule.
- Amount and timing of bait consumption.

**Which** brings **us** to the question of "control". Control is **difficult** to define and measure, as how many months with no tennite activity must pass before control is achieved? Subterranean termite populations are not static and movement occurs both within a population and among different species on any given property.

Forschler, in 1997, reported drastic reductions in termite activity at sites **that** were simply monitored over several years. Not surprisingly, both FirstLine and Sentricon users have experienced structures which go in and out of control through time. That a structure can become reinfested was also noted by Grace in 1997 where he described a structure in Hawaii **that** was infested with Formosan termites. Sentricon had controlled the infestation for 2.5 years, but later the structure became infested with Formosan tennites again in the same places as before. It was not known whether the tennites were from the same or another colony. The potential for the reuse of old soil tunnels is of concern.

Some Sentricon users have recognized the longer time frames needed to obtain control and have begun to develop two year programs. As, most STC situations result in the application of some tenniticide, at least some level of control can **begin** almost immediately. The slower elements, such as the use of monitors, baits, and the management of moisture and food will help to protect the structure over a longer time period.

It might be simpler to consider a tennite infested structure as a "patient" with a "disease". **If** the disease was present for a long time, more damage is done and treatment is more difficult and **takes** longer. Disease, found early, is more easily cured. It certainly appears **that** structures with a lot of termite history are more difficult to control compared to those with little or no history.

There is **a** need for long term monitoring and baiting of properties to effectively manage populations of subterranean tennites. The continued evolution of STC and other bait technologies is important for pest control companies to manage the paradigm shift initiated by the advent of tennite bait.

#### Conclusions: Bait Technology

- Sentricon and STC technology performed similarly in the first year as used by Orkin Pest Control in Florida.

- The monitors used in the STC program required about 3 months to get hits on most structures and the baits another

3-8 months to begin getting control.

- Actively infested properties resulted in more and faster infestation of monitors and or baits and took longer to get control.
- Properties treated preventatively got fewer hits, took longer to get hits and fewer days were required to begin getting control.

#### **Conclusions: Orkin**

- STC and the use of monitors and baits **are** positive for the company and the right direction to go.
- STC is profitable for Orkin and the program will only get better as it evolves.
- Dedicated bait technicians and trucks **are** important to the success of the program.
- More customer interaction is positive in selling new business and in reducing liability.

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## FIELD AND LABORATORY TESTS OF SULFLURAMID TREATED CARDBOARD AND FIRSTLINE™ TERMITE BAITS

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

Two species of subterranean termites, *Reticulitermes flavipes* and *R. virginicus*, were tested in laboratory experiments for effects following exposure to sulfluramid treated cardboard at 100, 150, and 200 ppm. Laboratory tests were conducted using 5,000 termites in arenas consisting of 5 plastic containers, filled to a depth of 5-cm with sandy loam soil, **containing** 11 potential feeding sites (3, 1-em<sup>3</sup> pine blocks and a 4 X 11 -cm piece of cardboard) and **connected** by lengths of tygon tubing (2-rnrn ill). Termites were introduced into the first of the five interconnected plastic containers and 19 of sulfluramid treated cardboard was provided in the **fifth** container. Arenas were dismantled after 8 weeks and the number of termites counted. These tests indicated that the 150 and 100 ppm treatments provided higher cardboard consumption rates.

Field trials with sulfluramid treated cardboard (100 ppm) were conducted at 5 different locations. Fifty grams of treated cardboard were placed into active termite monitoring stations or adjacent to visible termite activity within structures. Cardboard consumption and presence/absence of termites at and away from bait sites was recorded in all trials. Termite monitors, into which treated cardboard was placed, have shown no termite activity since one month following bait placement. Of the structures treated using aboveground cardboard bait placements, termite activity was reduced after the first month of bait placement at all sites. However, two of the three baited structures required additional spot treatments to remove subterranean termite infestation. No termite activity has been recorded at any of these treatment sites for the last 4 years.

Tests are currently being conducted using FirstLine™ on 6 structures where termite activity has been monitored for 3-4 years prior to installation of the trial. Treatments were applied following label instructions using clusters of three monitors per conducive area for a total of 187 monitors in July, 1997. After two weeks, two structures had termites in four FirstLine™ monitors. Following bait tube placement of three bait tubes per active FirstLine™ monitor, termite feeding was recorded in one bait tube the following month. Between October 1997 and February 1998 no termite activity was recorded at any of the structures, probably due to heavy rainfall during that time. In March and April 1998, 7 additional monitors at two more structures have shown termite activity and 28 bait tubes have been installed. To date, 12 bait tubes have been completely consumed at four structures that have indicated termite activity in the FirstLine™ monitors. Two of the structures have shown no termite activity. The FirstLine™ trials are ongoing. It would appear from the laboratory and field tests we have conducted ~~that~~ sulfluramid treated cardboard baits, when used in conjunction with soil termiticide treatments, can be used to protect structures from subterranean termite infestation.

## FIELD TESTS OF SULFLURAMID BAITS AGAINST SUBTERRANEAN TERMITES

Roger E. Gold and Harry N. Howell, Jr.  
Department of Entomology, Texas A&M University  
College Station, TX 77843

Subterranean termites nest in the soil and forage both in the soil and above the soil. Once a cellulose source is located the termites make repeated round trips from their nest to the wood source and back to the nest. The use of feed-through termiticides (Abaits) **have** been proposed for the management of these pests. The control philosophy is to eliminate the termite colony by supplying the foraging termites with a supply of a cellulose substance, which **has** been treated with a pesticide. **As** the termites return to the nest after **feeding** on the treated substance, they will distribute this pesticide through out the colony just as they would a natural cellulose substance.

These feed-through termiticides can be placed in the soil to be found by foraging termites and can be placed at the exact point where the foraging termites are currently feeding on wood. This test was to determine the effectiveness of placing the feed-through termiticide only at the points of active foraging. Efficacy was measured by the elimination of active foraging at this location within the building.

Ten commercial structures with active subterranean termite infestations were used for the test. A feed-through termiticide consisting of 50 grams of cellulose material impregnated with 50 or 100 PPM of sulfluramid was placed at each active foraging site. The sites were visited monthly for 12 months. At each visit, consumption and any termite activity such as active foraging and swarming were recorded.

Consumption of the feed-through termiticide was high during the initial 2-3 months and then reduced to zero. By the end of the 12 months test period, there was no termite activity at any of the termiticide placement sites, but termite foraging activity appeared at other locations in 3 of the structures. No termiticide was placed at these new activity sites. Swarming occurred in 5 of the 10 structures within 12 months of the initiation of treatment.

Two other structures were treated by placing the same feed-through termiticide at points where termites **had** swarmed in the building and in the soil around the perimeter of the building. In these two cases, there was no subsequent feeding at the swarming locations, but there was continual feeding at the soil sites. Within 12 months, swarming re-occurred in one of these structures.

Some thoughts on feed through termiticides:

1. Should continual feeding by the termites be interpreted as a lack of control?
2. Should PCO's be **trained** in capture-mark-recapture techniques?
3. Does the use of feed-through termiticides alone protect a structure from future termite attack?
4. Should the cessation of feeding on feed-through termiticides placed at the point of foraging or around the perimeter be interpreted as colony elimination?
5. **What** % of the termite colonies feeding around the perimeter is also feeding on timber in the structure?
6. In case termites fail to feed on feed-through termiticides places around the perimeter,

## BAITING TECHNOLOGY FOR SUBTERRANEAN TERMITE CONTROL

Shripat T. Kamble and James W. Austin  
Department of Entomology, University of Nebraska  
Lincoln, NE 68583 -0816

Since the introduction of insecticides registered for controlling subterranean termites, the conventional procedures **have** historically been through point-of-entry applications and barrier treatments of soil injected insecticides (termiticides). The complete reliance on termiticides and resulting risk concerns in certain sensitive environments, **have** spawned interest in alternative control technologies. Termite bait development is not a new concept and it has been researched for years. But due to the increased awareness of soil and environmental contamination from termiticide applications, there has been renewed interest in developing baiting technology. Emerging from this concept are two proven active ingredients formulated as baits to control and suppress the subterranean termite infestations. These bait products with different modes of delivery include: a) Sentricon®, Sentricon A.G.® (Dow Agroscience) contain an IGR, hexaflumuron, a benzoylphenyl urea (BPQ derivative **that** inhibits chitin synthesis, b) Firstline™ and Firstline GT™ (FMC), containing the stomach toxicant N-Ethyl perfluorooctanesulfonamide (sulfluramid). Preliminary field data suggest that subterranean termites will actively feed on these bait-products for several months before acquiring a toxic dosage. Cessation of feeding has been observed in some instances, but manipulation of the bait stations has proven to be effective in prompting subterranean termites to resume feeding. In other studies, no cessation of feeding was ever recorded. To date, we are still monitoring several populations in the Lincoln and Omaha areas, with promising results.

PROTECTION OF HISTORICAL AND ARTISTIC STRUCTURES IN ITALY  
AGAINST SUBTERRANEAN TERMITE *RETICUL/TERMES LUCIFUGUS* (ISOPTERA:  
RHINOTERMITIDAE) BY MEANS OF HEXAFLUMURON BAITS.

Roberto Ferrari<sup>1</sup>, Jean-Louis Leca<sup>2</sup>, Mario Marini<sup>3</sup>,  
and Valeria Zaffagnini<sup>4</sup>

- 1) Tecnic Scientific Service Sireb - Str. Collegara n' 27/1 - 41010 Modena -Italy
- 2) Dow AgroSciences Europe - Buropolis B.P. 229, 1240 Route des Dolines -06904  
Sophia Antipolis Cedex - France
- 3) Università di Bologna - Dipartimento Biologia Evoluzionistica e Sperimentale  
- Via Selmi n' 3 - 40126 Bologna - Italy
- 4) Dow AgroSciences **BY** - Via D'Azeglio n' 25 - 40123 Bologna - Italy

**ABSTRACT** This research was carried out in historical sites such as Bagnacavallo (near Ravenna) and in Rome (Campidoglio complex) where severe damages to **artistic** wood structures were caused by well established termite populations of *Reticulitermes lucifugus* (Rossi). In these sites, buildings are not standing alone and share common walls and foundations with surrounding properties. These non isolated buildings make any traditional chemical termite control useless. The bait technology based on the delivery of impregnated cellulose matrix with hexaflumuron, an insect growth regulator, was implemented. After a monitoring phase a number of underground and above ground stations were installed outside and inside the buildings. Minimum environmental disturbance and damages to the structures were caused. This baiting process was put in place in 1996 and 1997 using a 0.5% hexaflumuron bait matrix, and several station prototypes. Four different large structures were chosen for their high historical value: a church, a museum, a monastery and a library, all of them with a well-known past history of heavy **termite** infestation for many years. In the monastery the termite foraging territory and the size of the population were characterized by implementing the Triple Mark Recapture technique. The population was estimated at 1,070,000 ~**90,200** termites with a minimum of 1500 sqm foraging territory. The **maximum** linear distance covered by a single marked worker was 45m. In this site termite activity ceased in september 1996 after 8 months of baiting. In the spring of 1997 a reinfestation occurred from a neighbouring building which was easily controlled after 2 months of additional baiting preventing new structural damages. In total 3.4g of hexaflumuron were consumed. In the museum and the church, termite colonies were eliminated in September 1996 after six months of baiting. In the church a similar reinfestation occurred during the summer of 1997 which was successfully controlled after 4 months of baiting. The total amount of hexaflumuron consumed was 0.43g at the museum and 2.8g at the church. Finally, in the Campidoglio library in Rome the colony was wiped out after only three months of baiting with a total of 1.39 of active principle consumed.

**KEY WORDS** Termite, *Reticulitermes lucifugus*. Triple Mark Recapture, bait station, colony elimination.

## A NEW BAIT ATTRACTIVE TO MULTIPLE SPECIES OF ANTS

David F. Williams, Karen M. Vail", and David H. Oi

USDA-ARS, Center for Medical, Agric. And Vet. Entomology  
1600 SW 23<sup>rd</sup> Drive  
Gainesville, FL 32608

\*Extension Entomol. & Plant Pathol., Univ. of Tennessee  
P.O. Box 1071  
Knoxville, TN 37901-1071

A myriad of factors such as, seasonal preferences, nutritional requirements, and alternative food sources influence the foraging and acceptance of baits by ants. In addition, ant specificity to baits is affected by the active ingredient and the attractant used in the bait. For example, a bait that uses a soybean oil attractant and 1% fenoxcarb as its active ingredient will be readily **accepted** by imported fire ants but not by Pharaoh ants unless the fenoxcarb concentration is reduced. However, some ants will not accept oil attractants and will not feed on these types of baits regardless of the concentration of active ingredient. Despite the complexities of bait acceptance, liquid carbohydrate food sources are consistently fed upon by many **species** of ants. Thus, a new carbohydrate **based**, liquid attractant (hereafter referred to as MAB for multiple ant species bait) was developed.

In laboratory **studies**, MAB was found to attract more ants than a 9:1 sucrose:water or a 1:1 honey:water solution for the following species of ants: Argentine [*Linepithema humile*], crazy [*Paratrechina longicornis*], ghost [*Tapinoma melanocephalum*], and Florida carpenter [*Camponotus floridanus*] ants. In addition, for Pharaoh ants [*Monomorium pharaonis*], *Pheidole dentata*, *P. megacephala*, white-footed ants [*Technomyrmex albipes*], little fire ants [*Wasmannia auropunctata*], an acrobat ant species [*Crematogaster pilosa*], and *M. trageri*. the MAB had equal acceptance to that of the sugar and honey water solutions.

A water soluble toxicant [USDA-ARS, A13 no. 10750J was incorporated into the MAB and provided to groups of Argentine, Florida carpenter, or ghost ant workers. A delayed mortality response was observed for all species with mortality for the first day after exposure at less **than** 10% and followed by greater than 90% mortality within 8 days. Exposures to small colonies of Argentine ants resulted in greater than a 95% reduction in workers and brood within 2 weeks and eliminated all queens in 6 weeks. Exposure to ghost ant colonies resulted in greater than 99% mortality in workers and 100% reduction in brood and queens in 3 weeks. Florida carpenter ant colonies (workers and brood only) had over 95% reductions in 3 weeks. Pharaoh ant colonies had 90% or greater reductions for workers, brood and queens in 2 weeks and 100% mortality in 4 weeks. Red imported fire ant colony exposures resulted in the fastest mortality with all workers, brood and queens dead at 2 weeks. A patent application was submitted for the MAB in Dec. 1994.



## FOOD FLOW AND TROPHALLAXIS AMONG ARGENTINE ANTS, *LINEPITHEMA HUMILE* (MAYR)

Michael K. Rust and Linda M. Hooper  
Department of Entomology, University of California  
Riverside, CA 92521

The Argentine ant, *Linepithema humile* (Mayr) is one of the most important agricultural and urban pest ant species in the world. **Insecticidal** sprays have been widely used to control ants with varying degrees of success. Usually these sprays contact only the above ground foragers which comprise of about 10% of the colony. However, the use of toxic baits to kill Argentine ants is promising. Not only are the toxicants delivered to other workers, but also they are delivered to the queen and the larvae. Also, baiting allows for the reduction in the amount of active ingredient applied and appear to provide improved control. Unfortunately the flow of nutrients, baits, and toxicants in Argentine ant colonies is largely unknown.

To characterize trophallaxis and to determine the flow of food in the colony, radio-labeled nutrients were provided to the colonies. Trophallaxis characterization was accomplished using accelerator mass spectrometry (AMS) while food flow studies utilized liquid scintillation counting (LSQ). Workers often consume about 0.3  $\mu$ l of 20% sucrose solution at one feeding which is about equivalent to their body weight. Although queens weigh **almost** ten times more than workers, they consume about the same amount of liquid during one feeding. During trophallaxis about 50% of the meal is transferred from the donor ant to the recipient ant. Sucrose is shared **with** all developmental stages and castes. However, queens and males are fed before the immatures. Workers only feed larvae a solution of proteins. The larvae receive 55% of a 15% casein (protein) + 20% sucrose solution. The queens and males receive about 10% and 24%, respectively. The remaining 11% is fed to other workers. Workers are apparently capable of detecting very minute quantities of casein (0.001%) in a sucrose solution. However, workers more readily feed larvae if the concentrations are higher. Queens and newly eclosed workers are not fed protein unless it is combined with 20% sucrose.

A better **understanding** of the dynamics of trophallaxis and nutrient flow should **permit us** to develop more effective baits for ant control.

THE EFFECT OF HYDRAMETHYLNON AND FIPRONIL ON FOOD FLOW AMONG ARGENTINE  
ANTS, *LINEPITHEMA HUMILE* (MAYR)

Linda M. Hooper and Michael K. Rust  
Department of Entomology, University of California  
Riverside, CA 92521

The Argentine ant, *Linepithema humile* (Mayr) is one of the most important agricultural and urban pest ant species in the world. Recently, promising toxic baits have been produced to kill Argentine ants. Toxic baits capitalize on the trophallaxis behavior that occurs in ant colonies. Foraging workers gather the bait liquid or particles and transfer the bait to other members of the colony. This technique allows for more specific targeting of the queen and the developing brood to contact the toxicant. Also, baiting allows for the reduction in the amount of active ingredient applied and appears to provide improved control. Unfortunately the amount of active ingredient it takes to kill workers and queens and effect of the added toxicants on the flow of nutrients and distribution of baits in Argentine ant colonies are unknown.

Using accelerated mass spectrometry (AMS), we were able to determine the amount of hydramethylnon and fipronil required to kill workers and queens. We also investigated the distribution of each of the compounds in the bodies of the workers and the queens. There was more of each toxicant found in dead workers and queens than in live workers and queens. Interestingly, the dead queens contained much less of both hydramethylnon and fipronil per microgram of tissue than did the dead or live workers. The majority of fipronil that was found in live queens was in the head. In dead queens, fipronil was found in the thorax in the highest amounts.

We also performed experiments to determine if toxicants affected the flow of nutrients through Argentine ant colonies. Fipronil, which was recently registered for use in California, slightly increased the rate of nutrient flow through the colonies. The pattern of nutrient flow throughout the colony was not altered when lethal concentrations of fipronil were added to the nutrient solutions. Lethal concentrations of hydramethylnon decreased the rate of nutrient flow within the colonies. The pattern of nutrient flow throughout the colony changed dramatically when hydramethylnon was added to the nutrient solutions. At 4 hours, 0.1% hydramethylnon in a 20% sucrose solution was not fed to the queens as occurred when the sucrose was offered alone. Hydramethylnon when combined with sucrose and protein was not transferred as quickly to other workers than the controls without hydramethylnon. Hydramethylnon with sucrose and protein was not fed to the larvae or the queens at all.

A better understanding of the amount of toxicant required to achieve control and the effects of toxicants on nutrient distribution should permit us to reduce the levels of toxicants provided and develop more effective baits for ant control.

## ANT PHEROMONES AS ATTRACTANTS AND REPELLENTS FOR ARGENTINE ANTS

Les Greenberg and John H. Klotz  
Department of Entomology, UC Riverside  
Riverside, CA 92521

We investigated whether the Argentine ant trail pheromone, cis-9-hexadecenal, could **enhance** recruitment to solid and liquid baits. In the laboratory we used a 10% sucrose solution as a liquid bait. We tested pheromone concentrations ranging from 0.01 to 100  $\mu\text{g}$  of pheromone per ml of hexane solution. A 20  $\mu\text{l}$  drop of each solution was put onto a depression slide. After the hexane evaporated we put 50  $\mu\text{l}$  of the sucrose solution directly over the pheromone and stirred the solution with the pipette. This slide and a second slide with only the sucrose solution were placed side by side in the foraging areas of three Argentine ant colonies. Over a 30 minute period we counted the number of ants feeding at the sucrose solution on each slide. The optimal concentration for bait enhancement was with the 10  $\mu\text{g/ml}$  solution of pheromone: the number of ants feeding was increased by 250%.

In the field test of the trail pheromone we used 50 ml vials containing 10% sucrose solution. These vials were covered with a plastic membrane that has 1.5 mm diameter holes punched uniformly across its surface. Ants could drink from the holes after the vials were inverted. For half of the vials, 100  $\mu\text{l}$  of a 10  $\mu\text{g/ml}$  hexane solution of the pheromone was pipetted onto the plastic membrane before the vials were filled with sucrose. The hexane quickly evaporated, leaving the pheromone residue on the membrane. One control and one pheromone vial were taped side-by-side to a tree that had an active trail of Argentine ants. We placed 23 paired replicates on the trees for about 4 hours. After that time we measured the amount of sucrose consumed in each vial. Bait consumption with the pheromone was enhanced by 29%. In a second series of tests 12 pairs of vials were left **outside** for about 24 hours. The consumption rate was 33% higher with the pheromone.

We tested the trail pheromone with a solid, granular bait by applying 100  $\mu\text{l}$  of a 10  $\mu\text{g/ml}$  hexane solution of the pheromone to a rubber septum. After the hexane evaporated, two of these rubber septa were placed in a petri dish containing the bait. This dish and a second dish containing only the bait were placed side by side on the ground near an Argentine ant foraging trail. After several hours the consumption of bait was measured. There was a 64% increase in bait consumption when the pheromone was present.

To look at repellents we examined some of the easily obtained defensive pheromones from other **ants** in the subfamily Dolichoderinae. The bioassay consisted of placing the pheromone extract on the bottom of a watch glass. A second, smaller watch glass in the center contained a liquid food. The ants had to cross over the tested pheromone to reach the food. A control watch glass without pheromone was placed next to the trial dish. We counted the number of ants feeding at each dish every 3 mins over a 45 minute period. Each test was replicated with 3 colonies of ants. Although some repellency was evident with all of the compounds, the greatest longevity was observed with whole body extracts of the black velvety tree ant, *Liometopum luctuosum*. These extracts remained repellent to the Argentine **ants** even after 2 weeks. The pheromones of this species have not yet been identified.

## *SOLENOPSIS INVICTA* (BUREN) MOUNDS AS *RETICULITERMES* SPP. HABITATS

Thomas G. Shelton, J.T. Vogt, Arthur G. Appel, and Faith M. Oi

Subterranean termites in the genus *Reticulitermes* were observed inhabiting the mounds of the Red imported fire ant, *Solenopsis invicta* (Buren) during early spring of 1997. A survey of 100 RIFA mounds was conducted along four treeline transects, and one building perimeter, in Lee and Tuskegee counties, Alabama. Nineteen of these mounds contained *Reticulitermes* spp. termites either in the soil of the mound or in termite foraging material within these mounds. Caste proportions were determined from soil samples taken from the termite infested mounds. The significance of the termites within these mounds, including the circumstances of their presence is discussed. A discussion of further experimentation aimed at identifying the nature of the relationship between these species is presented.

# RED IMPORTED FIRE ANT (*SOLENOPSIS INVICTA* BUREN) FLIGHT ENERGETICS.

J.T. Vogt and A. G. Appel  
Department of Entomology, 301 Funchess Hall  
Auburn University, AL 36866

## ABSTRACT

*Solenopsis invicta* Buren, the red imported fire ant, is an important and abundant insect in the southeastern U.S. The conspicuous mounds, the stinging habits of the workers, and their effectiveness as predators of both pest and beneficial organisms combine to lend interest to this species, to scientists and lay persons alike.

Researchers have estimated that this species has spread at an average rate of 5 miles/year since its introduction into Mobile, Alabama in the late 1930s, primarily via mating flights. Flights of 10 miles or more have been reported. The female alate has a limited store of nutrients upon leaving the nest, and must fly, mate, construct a nuptial chamber in the soil, and feed and rear her first brood, all without feeding, in order to successfully found a colony.

A simple circular flight mill was employed to determine flight speed for male and female alates at different temperatures. Additionally, O<sub>2</sub> consumption of tethered, flying female ants was measured using closed-system respirometry. Flight mill speeds indicated that a female alate can fly approximately 1.4 miles in one hour, expending approximately 20 J (energetic equivalents calculated from closed-system respirometry). Flight, therefore, represents a significant cost to the animal and female alates are likely limited in the time they can spend aloft while retaining enough reserves to carry out colony founding. Our data suggest that wind is a very important dispersal agent for this insect, and is the primary factor involved in high (>5 mile) dispersal distances reported in the literature.

# CUTICULAR HYDROCARBONS AND SOLDIER DEFENSE SECRETIONS FOR CHEMOTAXONOMY OF *RETICULITERMES* IN NORTH AMERICA

Michael I. Haverty<sup>1</sup>, Lori J. Nelson<sup>1</sup>, Brian T. Forschler<sup>2</sup>, Laurence G. Cool<sup>3</sup>, and Marion Page<sup>1</sup>

<sup>1</sup> Chemical Ecology of Forest Insects, Pacific Southwest Research Station, USDA Forest Service, P.O. Box 245, Berkeley, CA 94701

<sup>2</sup> Department of Entomology, University of Georgia, Athens, GA 30602

<sup>3</sup> Forest Products Laboratory, University of California, Richmond, CA 94804

REFERENCE: Haverty, M.I., L.J. Nelson, B.T. Forschler, L.G. Cool, M. Page. 1998. Cuticular hydrocarbons and soldier defense secretions for chemotaxonomy of *Reticulitermes* in North America. Proceedings of the National Conference on Urban Entomology, 1998.

ABSTRACT: Cuticular hydrocarbon mixtures and soldier defense secretions from samples of *Reticulitermes* collected from disparate locations in Georgia, New Mexico, Arizona, Nevada, and California were characterized and correlated with species determinations. Hydrocarbons from the following classes have been found: normal alkanes, alkenes with 1 to 5 double bonds, terminally branched and internally branched monomethyl alkanes, dimethyl- and trimethylalkanes. Soldier defense secretions are comprised of 38 terpenoid compounds, including monoterpenes, sesquiterpenes, and a diterpene alcohol, geranyllinalool. The sesquiterpenes include  $\gamma$ -eadiene,  $\gamma$ -cadinene aldehyde, germacrene A,  $\alpha$ -,  $\beta$ -, and  $\gamma$ -himachalene, B-amorphene, and  $\beta$ -farnesene, and numerous minor and unknown compounds. Some soldier defense secretions phenotypes correlate with more than one cuticular hydrocarbon phenotype, however each hydrocarbon phenotype is correlated with only one soldier defense secretion phenotype. On the basis of these chemical characterizations, we suggest that there are numerous undescribed taxa of *Reticulitermes* and conclude that the taxonomy of this genus in North America is in need of revision.

KEYWORDS: subterranean termites, cuticular hydrocarbons, terpenes, soldier defense secretions

**COMPARISONS OF SINGLE AND GROUP BIOASSAYS ON ATTRACTION AND ARRESTMENT OF  
*RETICULITERMES SPP.(ISOPTERA: RHINOTERMITIDAE)* TO SELECTED  
CELLULOSIC MATERIALS**

Steven B. Suoja, Vernard R. Lewis, and David L. Wood  
Department of Environmental Science, Policy, and Management  
Division of Insect Biology, 201 Wellman **Hall**  
University of California  
Berkeley, CA 94720-3112

Abstract no available.....

## IPM IN TENNESSEE'S SCHOOLS?

Karen M. Vail, Assistant Professor  
Ent. & Pl. Path. Section, University of Tennessee  
Knoxville, TN 37901-1071

An Integrated **Pest Management** (IPM) in Schools Program was initiated **as** a joint venture between The University of Tennessee Agricultural Extension Service and The Tennessee Department of Agriculture, Division of Regulatory Services. To determine adoption of IPM in Tennessee's schools, a survey was distributed to the 149 public school systems. Survey results would be used **as** a baseline to determine future impact. Results from the survey, which had a 74% return, indicate much progress is needed to reduce the risk of unnecessary pesticide exposure to school occupants. Although 64.5% of respondents were concerned about pesticide exposure to school occupants, only 30% of schools claim they use IPM. This 30% is questionable because 77% of the respondents indicated that pesticides were scheduled and sprayed on a monthly basis. At least 7% did not understand the definition of IPM. Without a pest management policy, a school lacks goals and expectations for pest control. Almost 73% indicated they did not have a pest management policy.

There is still too much reliance on spraying and spot spraying of classrooms (79%); however crack and crevice treatments (65%) were used second most often. Less than 35% used other pest management methods (vacuuming, dusting, baiting or capture devices) which ideally would reduce pesticide exposure. One in five schools still uses foggers or thermal fog, although 19.1% never use aerosols or fogging. Even more discouraging is the fact that surface sprays are used all the time in 39% of the school systems. Food service areas receive the most intensive pesticide applications. Seventy-seven percent and 27% apply pesticides on a monthly basis and as needed, respectively, for the food service areas. Only 11% applied pesticides on a monthly basis to the grounds and 45% applied them **as** necessary to this area. Grounds do not receive pesticides as frequently as indoor locations.

Pesticide storage was another concern that was addressed with this survey. While 80% used the pest control contractor to store pesticides, 18% stored pesticides either on-site, at a district storage area or a district warehouse with other items.

Our decision to target the pest control industry **as** a first step proved to be right on target. A majority of pest control services were performed by contracted firms - 76% use contracted services only, 14% use contracted and school personnel, and only 9% use only school personnel for indoor pest control. Most **information** about **pest** management is obtained from the pest control contractor (75%), while the Agricultural Extension Service and vendors/manufacturers account for 27% and 26% of the information, respectively. The pest control technician is making the decisions of when and where to apply pesticides in 41% of the schools; however, the assumably untrained principal was responsible for 36% of these decisions. Almost 4 percent of the schools had an officially designated IPM Coordinator.

Respondents ranked pests from 1 to 10 with 1 being the most important. The following pests are listed (with their mode): cockroaches (1); head lice and ants/fire ants (2); rodents (3); spiders (4); wasps (5); and snakes, landscape pests, weeds and other (not ranked or 0). This was encouraging because the top 3 pests (excluding lice) can be managed through exclusion and sanitation practices and baits, thereby reducing the unnecessary risk of exposure to pesticides.

Past educational efforts included training pest control professionals which account for up to 90% of the pest control performed in Tennessee's public school systems. Future educational efforts will target the superintendents and others that make budget decisions for the school systems.



## EMERGING ARTHROPOD-BORNE DISEASES IN URBAN ENVIRONMENTS

James G. Olson

Viral and Rickettsial Zoonoses Branch, Centers for Disease Control and Prevention  
Atlanta, GA 30333

Arthropod-borne diseases include some of the most important diseases caused by parasites, bacteria and viruses. Historically, malaria, typhus, plague, yellow fever and scrub typhus have caused mortality and morbidity that made them scourges of mankind. Great progress in the control of vector-borne diseases has been made in the 20th century. The implementation of vector control strategies based on the use of DDT were directly responsible for nearly eradicating malaria from the Americas and Asia, for elimination of urban plague and for the simultaneous reductions of urban yellow fever and dengue fever. By the early 1970s arthropod-borne diseases were no longer considered to be of major public health importance. In contrast to the early and dramatic successes, we are now faced with dramatic reemergence of vector borne diseases previously controlled. Malaria causes 300-500 million cases resulting in 1.5 -2.5 million deaths annually. Nearly 100 million cases of dengue fever occur annually. With the reinvasion of tropical urban centers by *Aedes aegypti*, the risk of urban yellow fever outbreaks is increasing geometrically. The question is no longer **if** they will occur, but when and where. Although many of the factors that have been responsible for the global resurgence of vector-borne diseases are poorly understood, several **obvious** associations can be documented. The population of the earth is rapidly becoming urbanized. The growth of the large macro cities of the tropics will continue and the migration of rural populations into those cities largely for economic gain will serve to **maximize** the probability of introductions of diseases restricted to sparsely populated rural areas into urban settings. The international emergency in financial support for a decaying public health infrastructure has undoubtedly contributed to the problem. Periodic explosive outbreaks of Japanese encephalitis, West Nile fever, Rift Valley fever, Oropouche fever, Ross River fever and Chikungunya fever may occur.

Arthropod-borne diseases will continue to be a threat to the urban and suburban populations of the United States. The risk of cataclysmic morbidity and mortality is several orders of magnitude lower than in the tropics. However, several new diseases have emerged in the last few decades. Lyme disease, granulocytic ehrlichiosis, monocytic ehrlichiosis, Powassan encephalitis, and catflea typhus. Others, including St Louis encephalitis, flea-borne typhus, rickettsialpox and perhaps eastern equine encephalitis and western equine encephalomyelitis are increasing or threaten to increase in importance.

## A NEW BAIT ATTRACTIVE TO MULTIPLE SPECIES OF ANTS

David F. Williams, Karen M. Vail\*, and David H. Oi

USDA-ARS, Center for Medical, Agric. And Vet. Entomology  
1600 SW 23<sup>rd</sup> Drive  
Gainesville, FL 32608

\*Extension Entomol. & Plant Pathol., Univ. of Tennessee  
P.O. Box 1071  
Knoxville, TN 37901-1071

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A water soluble toxicant [USDA-ARS AD no. 10750J was incorporated into the MAE and provided to groups of Argentine, Florida carpenter, or ghost ant workers. A delayed mortality response was observed for all species with mortality for the first day after exposure at less **than** 10% and followed by greater **than** 90% mortality within 8 days. Exposures to small colonies of Argentine ants resulted in greater than a 95% reduction in workers and brood within 2 weeks and eliminated all queens in 6 weeks. Exposure to ghost ant colonies resulted in greater **than** 99% mortality in workers and 100% reduction in brood and queens in 3 weeks. Florida carpenter ant colonies (workers and brood only) had over 95% reductions in 3 weeks. Pharaoh ant colonies had 90% or greater reductions for workers, brood and queens in 2 weeks and 100% mortality in 4 weeks. Red imported fire ant colony exposures resulted in the fastest mortality with all workers, brood and queens dead at 2 weeks. A patent application was submitted for the MAB in Dec. 1994.

CONFERENCE  
ATTENDEES  
IN ALPABETICAL FILE BY LAST NAME

Aho, Tom  
Aho Enterprises, Inc.  
140 E. Marvin Avenue  
Longwood, FL 32750  
407-339-4455

Anderson, A. L., Chip  
Bayer  
1029 Peachtree Parkway North #357  
Peachtree City, GA 30269  
770-632-9104  
chip.anderson.b@bayer.com

Appel, Arthur  
Auburn University, Dept. Entomology  
301 Funchess Hall  
Auburn, AL 36849-5413  
334-844-2562  
aappel@acesag.auburn.edu

Atkinson, Tom  
Dow AgroSciences  
1021 Village Parkway  
Coppell, TX 75019  
972-304-4128  
thatkinson@dowagro.com

Austin, James  
University of Nebraska  
201 A Plant Industry Bldg.  
Lincoln, NE 68583-0816  
402-472-2076  
jwaustin@unlgrad1.unl.edu

Baker, Paul  
University of Arizona  
1109 E. Helen Street  
Tucson, AZ 85719  
520-621-4012  
pbaker@ag.arizona.edu

Baa, Nang-gong  
Clorox Services Co.  
7200 Johnson Drive  
Pleasanton, CA 94588  
925-847-6714

Barcay, John  
Ecolab Inc.  
840 Sibley Memorial Highway  
Mendota Heights, MN 55118  
612-451-5686

Barile, Joe  
The Clorox Company  
610 Ware Street  
Mansfield, MA 2048  
508-339-6077  
508-339-6077  
joe.barile@clorox.com

Barnes, Russ  
Allied Pest Control  
140 E. Marvin Avenue  
Longwood, FL 32750  
407-339-4455

Barrett, Billy  
Clemson University - Regulatory  
P.O. Box 21767  
Columbia, SC 29221  
803-772-0766  
jbbrrtt@clemson.edu

Baumann, Greg  
National Pest Control Association  
8100 Oak Street  
Dunn Loring, VA 22027  
703-573-8330

Baxter, Jim  
Dow AgroSciences  
9330 Zionsville Road  
Indianapolis, IN 46268  
317-337-4388  
jpbaxter@dowagro.com

Beal, Ray  
R&B Termite Specialist  
17 Alava Lane  
Hot Springs Village, AR 71909  
501-922-2022

Bello, Paul  
Zeneca  
1800 Concoed Pike  
Wilmington, DE 19897  
800-759-4500-1508  
302-886-1644

Bennett, Gary  
Purdue Dept Entomology  
West Lafayette, IN 47907  
765-494-4564  
765-494-0535  
gbennett@purdue.edu

Benson, Eric  
Clemson University  
105 Long Hall, Dept. Entomology  
Clemson, SC 29634  
864-656-3111  
ebenson@clemson.edu

Berman, Richard C.  
Waltham Chemical Co.  
817 Moody Street, Box 538  
Waltham, MA 22540538  
781-893-1810  
rcberman@aol.com

Bertsch, Marv  
I.C.R. Inc.  
1330 Dillon Heights Avenue  
Baltimore, MD 21228  
410-747-4500  
icr@erols.com

Bieman, Donald  
San Pedrito Institute, Inc.  
HC-44, Box 13444  
Cayey, Puerto Rico 736

Blaine, Dale  
PCO Services Inc  
170 Robert Speck Parkway  
Mississauga  
Ontario, Canada  
905-949-8778

Bledsoe, Mike  
Ecosciences  
4300 LB McLeod Rd., Ste. C  
Orlando, FL 32811  
407-872-2224

Blewett, T. Craig  
Dow AgroSciences  
9330 Zionsville Rd.  
Indianapolis, IN 46268  
317-337-4417  
tcblewett@dowagro.com

Boucias, Drion  
University of Florida  
Department of Entomology  
Gainesville, FL 32611-0620

Braness, Gary  
Bayer Corporation  
2160 Ellery Avenue  
Clovis, CA 93611  
209-323-6470

Buckle, Alan  
Zeneca Profession Products (UK)  
Femhurst, Maslemere, Surrey, Surrey  
United Kingdom GU27 3JE,  
1144428655568"  
alan.a.p.buckle@aguk.zeneca.com

Butler, John  
Solaris/Monsanto  
P.O. Box 768  
Moorestown, NJ 8057  
609-235-0850,  
john.j.butler@monsanto.com

Buzard, David  
U.S. Army – Ft. AP. Hill  
DPW Bldg. 1247  
Bowling Green, VA 22427  
804-633-8457

Cabrera, Brian  
University of California, Department of  
Entomology  
Riverside CA 92521  
909-787-5805  
Termite@citrus.ucr.edu

Canavan, Paul  
American Cyanamid,  
10 Boonton Ave  
Boonton, NJ 07005-8903

Carpenter, Tonia  
Rhone Poulenc  
POB 12014  
RTP, NC 27709-2014  
919-549-2029  
919-549-2563  
tcarpent@rp-agro.com

Cartwright, Bob  
Novartis Crop Protection  
410 Swing Road  
Greensboro, NC 27419  
336-632-6487  
336-632-2653  
bob.cartwright@cp.novartis.com

Cates, Jerry  
EntomoBiotics Inc.  
8411 Columbia Falls Drive  
Round Rock, TX 78681  
512-331-1111  
ebjcates@earthlink.net

Chambers, Mike  
Dow AgroSciences  
9330 Zionsville Rd., Bldg. 308/3A  
Indianapolis, IN 46268  
317-337-4386  
dmchambers@dowagro.com

Chapman, Michael  
Western Exterminator Company  
1732 Kaiser Ave.  
Irvine, CA 92614  
714-261-2440  
mchapman@pacbell.net

Chiao, Erica  
University of Georgia  
Dept. Entomology, 413 BioSciences Bldg.  
Athens, GA 30602  
706-542-0078  
echiao@bugs.ent.uga.edu

Chism, Bill  
Rhone-Poulenc Ag. Co.  
P.O. Box 258  
Point of Rocks, MD 21777  
301-874-6380  
bchism@rp-agro.com

Christensen, Chris  
Urban Insect Solutions  
287 Pasadena Drive  
Lexington, KY 40503

Cink, Jim  
Bayer  
23935 Scrivener Lane  
Katy, TX 77493  
281-347-4417

Cochran, Don  
Virginia Tech  
1205 Kings Landing Road  
Hampstead, NC 28443  
910-270-4406

Coffett, Dr. Mark A  
AgrEvo  
10920 Ambassador Drive  
Kansas City, MO 64153  
816-891-7580  
mark.coffett@agrevo.com

Colbert, Don  
American Cyanamid  
2133 Jackson St.  
Lodi, Ca 95242

Coltharp, Larry  
Solaris/Monsanto  
742 Horizon Drive  
Martinez, CA 94553  
510-355-3334  
510-355-3534  
john.l.coltharp@monsanto.com

Cooper, Richard  
Cooper Pest Control  
351 Lawrence Station Road  
Lawrenceville, NJ 08648  
609-799-1300  
phil@cooperpest.com

Copps, Patrick  
Prism,  
17959 Ajax Circle  
City of Industry, CA 91748  
800-67prism,,

Corrigan, Bobby  
RMC Consulting  
5114 Turner Rd.  
Richmond, IN 47374-9627  
765-939-2829

Cramer, Gary  
FMC  
2920 East Monte Vista Dr.  
Tucson, AZ 85716  
520-318-0705  
520-327-5683  
gary\_cramer@fmc.com

DeMark, Joe  
Dow AgroSciences  
876 Buckeye Lane West  
Jacksonville, FL 32259  
904-287-1971  
jjdemark@dowagro.com

Diaz, Steve  
Paragon Professional  
Pest Control Products

Dickens, Tim  
Scientific Coordination Inc  
4629 Cherry Valley Dr.  
Rockville, MD 20853  
301-570-4390  
dickensth@aol.com

Donaghy, Chris  
Residex Corporation  
225 Terminal Ave.  
Clark ,NJ 07066-1374  
732-381-6200

Donahue, Bill  
Sierra Research Laboratories,  
4852 Parker Road  
Modesto, CA 95357  
209-521-6380

Duan, Toma  
Griffin L.L.C  
2008 N. Sherwood Dr.  
Valdosta, GA 31602  
912-293-4242

Duckworth, Charles  
United Industries Corp.  
8825 Page Blvd.  
St. Louis, MO 63114  
314-427-0780

Dudor, Dave  
S.C. Johnson Wax  
1525 Howe Street  
Racine, WI 53403-2236  
414-260-3800  
dmdudor@scj.com

Dycus, Roman  
Terminix - Hawaii Region  
6700 Kalaniana'ole Highway #103  
Honolulu, HI 96825  
808-396-5044

Engraff, Barry  
American Cyanamid Co.  
P.O. Box 400  
Princeton, NJ 85430400  
609-716-2350  
engroffb@pt.cyanamid.com

Essex, Joe  
Sears Termite & Pest Control  
6359 Edgewater Drive  
Orlando, FL 32810  
407-291-8027

Fanow, Robert  
American Cyanamid  
P.O. Box 400  
Princeton, NJ 8543  
609-716-2680

Ferrari, Roberto  
Univ of Bologna  
Str. Collegara 27/1  
Modena, ITALY,  
395-446-8148  
diolodi@tin.it

Field, Herb  
Lloyd Pest Control  
935 Sherman Street  
San Diego, CA 922110  
619-686-1955  
field@intemetmci.com

Forschler, Brian  
University of Georgia  
Department of Entomology  
Athens, GA 30602",

Freytag, Ed  
New Orleans M&T Contral,  
6601 South Shore Harbor Blvd.  
New Orleans, LA 70126  
504-241-2370  
efreytag@usa.net

Gallo, Thomas  
Zeneca Professional Products  
16013 Watson Seed Farm Road  
Whitakers, NC 27891  
919-437-0337

Getty, Gail M.  
Pacific Southwest Research Stn.  
P.O. Box 245  
Berkeley, CA 94701  
510-559-6475  
ggetty@nature.berkeley.edu

Gold, Roger  
Texas A&M University, Department of  
Entomology  
College station, TX 77843  
409-845-5855  
r-gold@tamu.edu

Gordon, Jill M.  
Western Pest Services  
905 Route 10  
Randolf, NJ 07869  
973-584-0900  
drfillr1@aol.com

Gordon, Ken  
Gordon Termite Control  
4939 Eane Ave  
Rosemead, CA 91770

Grace, Ken  
University of Hawaii  
Dept. Entomology 3050 Maile Way  
Honolulu, HI 96822-2271  
808-956-6744  
kennethg@hawaii.edu

Granovsky, Ted,  
Granovsky Associates, Inc.  
3206 Wildemess Road  
Bryan, TX 77807-3221  
409-822-3069  
ted@granovsky.com

Greenberg, Les  
University of California  
Department of Entomology  
Riverside, CA 92521  
909-787-3888  
les.greenberg@ucr.edu

Hathorne, Kevin  
Clemson University  
114 Long Hall, Dept. of Entomology  
Clemson, SC 29634  
864-656-0940  
kevinh@clemson.edu

Grow, Russ  
Orkin Pest Control  
25 Hunns Lake Road  
Stanfordville, NY 12581  
914-868-7191  
in2bugs@aol.com

Haverty, Mike  
U.S. Forest Service  
P.O. Box 245  
Berkeley, CA 94701  
510-559-6478  
mhaverty/psw@fs.fed.us

Gulmahamad, Hanif  
Terminix International  
1501 Harris Court  
Anaheim, CA 92806  
714-939-8791

Hawkins, Lyndon  
Dept Pesticide Regulation  
POB 1775  
Elk Grove, CA 95759  
916-685-3764

Haas, Keith  
Granovsky Associates, Inc.  
3206 Wildemess Road  
Bryan, TX 77807-3221  
409-822-3069  
keith@granovsky.com

Hawks, Bill  
Hawks Inter-State,  
Wichita, KS

Hamilton, Robert  
S.C. Johnson Wax  
1525 Howe Street  
Racine, WI 53403-2236  
414-260-4589  
rihamilt@scj.com

Henderson, Gregg  
Louisiana State University  
Department of Entomology  
Baton Rouge, LA 70803  
504-388-1831  
ghender@unix1.sncc.lsu.edu

Hanney, Craig  
Van Waters & Rogers, Inc.  
6100 Carillon Point  
Kirkland, WA 98033  
206889340"

Higo, Akio  
McLaughlin Gormley King Co.  
8810 Tenth Avenue North  
Minneapolis, MN 55427  
612-544-0341  
akihigomgk@aol.com

Hansen, OLaurel D.  
Spokane Falls College  
3410 W. Fort Wright Drive  
Spokane, WA 99224  
509-533-3666  
laurelh@sfcc.spokane.cc.wa.us

Hinkle, Nancy C.  
University of California  
Department of Entomology  
Riverside, CA 92521  
909-787-2422  
nhinkle@citrus.ucr.edu



Holbrook, Glenn L.  
North Carolina State University  
Department of Entomology  
Raleigh, NC 27695-7613  
919-515-1820  
glenn\_holbrook@ncsu.edu

Hooper, Linda M.  
University of California  
Department of Entomology  
Riverside, CA 92507  
909-787-5805  
lhopper@ucr.edu

Hope, Joe  
Rhone Poulenc  
2 T.W. Alexander Dr.  
RTP, NC 27709  
919-549-2703

Houseman, Richard  
Texas A&M University  
Department of Entomology  
College Station, TX 77843  
409-845-5855  
mouse@tamu.edu

Howell, Harry  
Texas A&M University  
Department of Entomology  
College station, TX 77843  
409-845-5855

Hutto, Darrell  
HPC Services  
20714 Harvest Hill  
Houston, TX 77073-3112  
281-821-4440

Ivey, John  
Bayer  
Box 390  
Shawnee Mission, KS 66201-0390  
913-268-2039

Jacobs, Steve  
Penn State University  
Department of Entomology  
Univ. Park, PA 16802  
814-863-3963  
sbj2@psu.edu

Jelks, Veronica R.  
University of Georgia  
Department of Entomology  
Athens, GA 30602

Jenkins, Tracie  
University of Georgia  
Department of Entomology  
Athens, GA 30602

judy, Dick  
Lesco, Inc.  
20005 Lake Road  
Rocky River, OH 44116-1545  
800-321-532-5216  
bugs05@aol.com

Kamble, Shripat T.  
University of Nebraska  
Department of Entomology, 201 PI  
Lincoln, NE 68583-0816  
402-472-6857  
skamble@unlinfo.unl.edu

Kard, Brad,  
U.S. Forest Service  
P.O. Box 10234, GMF  
Gulfport, MS 39505

Kaukeinen, Dale  
Zeneca Professional Products  
2317 Paulwynn Road  
Wilmington, DE 19810  
302-886-5656  
dale.kaukeinen@agna.zeneca.com

Kelley-Tunis, Kim  
McCloud Services  
1811 Executive Drive, Ste. G  
Indianapolis, IN 46241  
317-244-1604  
kim.kelleytunis@msn.GOm

Kendall, Ken,  
Ensystem, Inc.  
P.O. Box 2587  
Fayetteville, NC 28302  
910-484-6163  
ken@ensystem.com

Kenmuir, Sylvia  
Target Specialty Products  
15415 S. Marquardt Avenue  
Santa Fe Springs, CA 90670  
562-802-2238

King, Ed  
Dow AgroSciences  
9330 Zionsville Rd.  
Indianapolis, IN 46268  
317-337-4924  
jeking@dowagro.com

Klein, Chuck  
American Cyanamid Company  
1253 Melissa Lane  
Ville Platte, LA 70586  
318-461-2798  
kleinC@pt.cyanamid.com

Klotz, John  
University of California  
Department of Entomology  
Riverside, CA 92521  
909-787-3898  
jklotz@ucr.edu

Koehler, Margie  
AgrEvo  
19245 Beckonridge Lane  
Huntington Beach, CA 92648  
714-536-0362  
deankoe@aol.com

Kukorowski, Ken  
Rhone-Poulenc  
POB 12014  
RTP, NC 27709-2014  
919-549-2552  
kkukorow@rp-agro.com

Lacey, Mark  
Paragon Prof. Products  
1800 Marshall Ave  
Wilmington, DE 19808

Laursen, Craig  
Zeneca  
2365 Valley View Place  
Escondido, CA 92026  
760-735-8048  
760-735-8019  
craig.laursen@agna.zeneca.com

Lawton, Michael  
Western Exterminator Company  
1732 Kaiser Avenue  
Irvine, CA 92614  
714-261-2440

Lax, Alan  
USDA Southern Regional Res. Center  
1100 Robert E. Lee  
New Orleans, LA 70124

Lee, Roger  
Clorox Services Co.  
7200 Johnson Drive  
Pleasanton, CA 94588  
925-847-6922

Lesiewicz, Don  
AgrEvo  
95 Chestnut Ridge Road  
Montvale, NJ 07645  
201-307-3389  
don.lesiewicz@agrevo.com

Lewis, Donald  
Iowa State University  
104 Insectary  
Ames, IA 50011  
515-294-1101  
drlewis@iastate.edu

Lewis, Vernard  
UC Berkeley  
Insect Biology 201 Wellman Hall UCB  
Berkeley, CA 94720

Liang, Dangsheng  
Clorox  
7200 Johnson Dr  
Pleasanton, CA ,94588-8004

Lovelady, Clark  
Granovsky Associates, Inc.  
3206 Wilderness Road  
Bryan, TX 77807-3221  
409-822-3069  
clark@granovsky.com

Lubbert, R. Trevor  
National Institutes of Health  
13 South Drive, MSC 5710, G807  
Bethesda, MD 20892-5710  
301-496-4294  
doc1 @box-d.nih.gov

Macom, Tom  
Texas A&M University  
Department of Entomology  
College Station, TX 77843  
409-845-5855  
temacom@tamu.edu

Mares, Joe  
Griffin L.L.C.  
2509 Rocky Ford Rd.  
Valdosta, GA 31603  
912-293-4242

Marks, Mel  
U.S. Navy  
Box 190010  
North Charleston, SC 29419-9010  
843-820-7019

Martinez, Manny  
Rhone Poulenc  
2 T.W. Alexander Dr.  
RTP, NC 27709

McClellan, Bill  
Zeneca Professional Products  
1800 Concord Pike  
Wilmington, DE 19803-2910  
800-759-4500

McClure, Jack  
Chemtech Supply Inc.  
1905 S. Macdonald #8  
Mesa, AZ 85210  
602-833-7578

Meiracker, Kristen van den  
Clemson University  
114 Long Hall, Dept. of Entomology  
Clemson, SC 29634  
864-656-0940  
wanden@clemson.edu

Melichar, Mike  
Dow Agro Sciences  
P.O.Box 681338  
Indianapolis, IN 46268

Meola, Roger  
Texas A&M University  
Department of Entomology  
College Station, TX 77843-2475  
409-845-9748  
rwmeola@tamu.edu

Merchant, Michael  
Texas Agricultural Extension  
17360 Coit Road  
Dallas, TX 75252-6599  
214-952-9204  
214-952-9204  
m-merchant@tamu.edu

Messenger, Matt  
New Orleans M&T Board  
6601 South Shore Harbor Blvd.  
New Orleans, LA 70126  
504-241-2370  
mmesseng@usa.net

Metzger, Marco E.  
University of California  
3401 Watkins Drive  
Riverside, CA 92521  
909-787-5805  
metzger@citrus.ucr.edu

Miko, Judi  
Sumitomo Chemical Co. Ltd.  
607 E. Frederick Street  
Arlington Heights, IL 60004  
847-506-0254  
xbugs@aol.com

Nelson, Lori  
U.S. Forest Service  
P.O. Box 245  
Berkeley, CA 94701  
510-559-6478  
lnelson/psw@fs.fed.us

Mitchell, Mike  
Sola ris/Monsanto  
P.O. Box4356  
Tyler, TX 75712  
903-592-5744  
michael.g.mitchel@monsanto.com

Nichols, Phil Doc  
Sears Termite & Pest Control  
6359 Edgewater Drive  
Orlando, FL 32810  
407-291-8027

Monke, Bruce J.  
Bayer Corporation  
8400 Hawthorn Road  
Kansas City, MO 64120-0013  
816-242-4712  
bruce.monke.b@bayer.com

Nichols, Jo Ellen  
Zeneca Professional Products  
16013 Watson Seed Fann Road  
Whitakers, NC 27891  
919-437-0338

Monks,Trevor  
14 Parik Ave. Oatley  
Sydney NSW, Australia,

Nishimura, Tom  
American Cyanamid  
2600 NE Minnehaha St.  
Vancouver, WA 98665  
360-696-3496

Moreira, Eduardo  
Zeneca  
3841 NW 58th Avenue  
Gainesville, FL 32653  
352-337-1181  
eduardo.moreira@agna.zeneca.com

Oi, David  
USDA-ARS-CMAVE  
1600 SW 23rd Drive  
Gainesville, FL 32608  
352-374-5987  
doi@gainesville.usda.ufl.edu

Moreland, Dan  
Pest Control Technology Magazine  
4012 Bridge Avenue  
Cleveland, OH 44113  
2169614130  
dmoreland@gie.net

Oi, Faith M.  
Auburn University  
201 Extension Hall  
Auburn, AL 36849  
334-844-6399

Murphy, Glen  
Prism  
8300 Executive Center Drive  
Miami, FL 33166  
800-888-5777

Olsen, Chris  
Rhone-Poulenc  
40763 Calle Medusa  
Temecula, CA 92591  
909-506-4405  
colsen@rp-agro.com

Olson, James,  
3055 Randolph Road NE  
Atlanta, GA 30345  
770-496-0940

Pachamuthu. Pari  
University of Nebraska  
Department of Entomology, 201 PI  
Lincoln, NE 68583-0816  
402-472-6857

Paige, John H.  
Bayer Corporation  
8400 Hawthorn Road  
P.O. Box 4913  
Kansas City, MO 64120-0013  
816-242-4715

Paine, Eileen  
University of California  
Department of Entomology  
Riverside, CA 92521  
909-787-5805  
epaine@ucrac1 .ucr.edu

Parent, Jim  
Clorox Services Co.  
7200 Johnson Drive  
Pleasanton, CA 94588  
925-847-61 20

Porter, Tenry K.  
FMC Corporation  
Box 450  
Sparks, GA 31647  
912-549-8262  
tenry\_porter@fmc.com

Potter, Mike  
University of Kentucky  
Dept. Entomology, S225 Ag Sci. Center N.  
Lexington, KY 40546-0091  
606-257-2398,  
mpotter@ca.uky.edu

Potts, Lindsey  
IIPM Systems  
6031 John Chapman  
San Antonio, TX 78240-2268  
210-684-8838

Prabhakaran, Suresh K.  
University of Iowa  
100 Facilities Services Bldg.  
Iowa City, IA 52242-1520  
319-335-5123  
suresh-prabhakaran@uiowa .edu

Price, David A.  
Bayer Corp. Agriculture Division  
P.O. Box 1508  
Vera Beach, FL 32961-1508  
5615626549242"

Rachadi, Mohamed  
Waterbury Companies, Inc.  
P.O. Box 1812  
Waterbury, CT 6722  
203-597-1812

Racioppe, Stephen  
Whitmire Micro-Gen  
3568 Tree Court Industrial Blvd.  
St. Louis, MO 63122  
314-225-5371

Ramakrishnan, Rathna  
Steritech Env. Service  
7945 Silverton Ave., Ste. 1108  
San Diego, CA 92126  
619-547-6400  
entorathna@aol.com

Rambo, George  
George Rambo Consulting Services  
1004 Van Buren Street  
Herndon, VA 20170  
703-709-6364  
gramboiii@aol.com

Rasa, Cordelia  
Texas A&M Univ  
Dept. Entomology  
College Station, TX 77843

Read, Jim  
Clorox Services Co.  
7200 Johnson Drive  
Pleasanton, CA 94588  
925-847-6895

Records, Lon  
Target Specialty Products  
15415 Marquardt Avenue  
Santa Fe Springs, CA 90670  
800-352-3870

Reid, Byron  
American Cyanamid Co.  
P.O. Box 400  
Princeton, NJ 08543-0400  
609-716-2000

Reierson, Donald  
University of California  
Department of Entomology  
Riverside, CA 92521  
909-787-3609  
reierson@mail.ucr.edu

Resetar, Don  
Pest Control Services, Inc.  
P.O. Box 482  
Northbrook, IL 60065  
847-272-1337

Rettich, Frantisek  
National Inst. Public Hlth  
Srobarova 48  
Prague 10,  
Czech Republic 10042  
420267082566

Ring, Dennis  
Louisiana State University  
P.O. Box 125100  
Baton Rouge, LA 70894-5100  
504-388-2180  
dring@agctr.lsu.edu

RObertson, Sterett  
Dow AgroSciences  
9330 Zionsville Rd.  
Indianapolis, IN 46071  
317-337-4384  
asrobertson@dowagro.com

Robinson, Bill  
Urban Pest Control Research Center  
215 Price Hall  
Blacksburg, VA 24061  
540-231-4045  
upcrc@vt.edu

Root, Jack  
North and Root Consulting  
799 Road 2900  
Aztec, NM 87410  
505-334-1568  
northroot@cyberport.com

Roper, Elray  
Zeneca,  
Richmond, CA

Rose, Mike  
Montana State Univ  
Department of Entomology  
Bozeman, MT 95717-3020  
406-994-3860

Ruizzo, Michael A.  
Bayer Corporation  
8400 Hawthorn Road  
Kansas City, MO 64120-0013  
816-242-4712  
mike.ruizzo.b@bayer.com

Rulen, Jason  
WV Dept. of Agric.  
1900 Kanawha Blvd., East  
Charleston, WV 25305  
304-558-2209  
rulen\_ja@wvlc.wvnet.edu

Ryder, Jack  
Dow AgroSciences  
465 Cullen Copse  
Alpharetta, GA 30022  
770-667-5588  
jcryder@dowagro.com

Sargent, Jim  
Copesan Services  
3490 N. 127th Street  
Brookfield, WI 53005  
414-783-6261  
sarge@copesan.com

Sbragia, Ron  
Dow AgroSciences  
P.O. Box 1671  
Placerville, CA 95667  
530-295-9305  
rjsbragia@dowagro.com

Scheffrahn, Rudi  
University of Florida  
3205 College Ave.  
Ft. Lauderdale, FL 33314  
954-475-8940  
rhsc@icon.ftld.ufl.edu

Schneider, Brian  
Dow Agri Sciences  
9330 Zionsville Road  
Indianapolis, IN 46268

Schwalb, Ron  
Nisus Corporation  
215 Dunavant Drive  
Rockford, TN 37853  
800-264-0870  
nisus@tdsnet.com

Seabrook, Jeffrey  
Zeneca Professional Products  
1000 Brush Creek Road  
Argyle, TX 76226-1508  
940-383-4029  
bugsdoc1@msn.com

Seemann, Douglas  
University Termite & Pest  
3930 E. Tennessee  
Tucson, AZ 85714  
520-886-4146

Seymour, Phil  
Waltham Chemical Co.  
817 Moody Street, Box 538  
Waltham, MA 02453-5024  
781-893-1810  
rcberman@aol.com

Shapas, Ted  
Clorox Services Co.  
7200 Johnson Drive  
Pleasanton, CA 94588  
925-847-6337

Shelton, Thomas G.  
Auburn University  
301 Funchess Hall  
Auburn, AL 36849-5413  
334-844-2570  
shelttg@acesag.auburn.edu

Shodrock, Damon  
Dow AgroSciences  
17654 Beckfield Avenue  
Baton Rouge, LA 70817-7392  
504-752-7059  
dlshodrock@dowagro.com

Silverman, Jules  
Clorox Services Co.  
7200 Johnson Drive  
Pleasanton, CA 94588  
925-847-6851

Sims, Steven  
Whitmire Micro-Gen  
3568 Tree Court Industrial  
St. Louis, MO 63043  
314-225-5371  
steve\_sims@compuserve.com

Smith, Eric  
Dodson Brothers  
3712 Campbell Ave., POB 10249  
Lynchburg, VA 24506  
804-847-9051

Smith, Michelle S.  
Dow AgroSciences  
9330 Zionsville Road, 308/1A  
Indianapolis, IN 46268  
317-337-3952  
mssmith@dowagro.com

Smith, John F.  
Bayer Corporation  
10834 Belmont Circle  
Indianapolis, IN 46280  
317-582-1324  
jsmithbaygpC@worldnet.att.net

Smith, Lane  
Auburn University  
Dept. Entomology  
301 Funchess Hall  
Auburn, AL 36849-5413  
334-844-2734  
lsmith@acesag.auburn.edu

Smith, Jim  
Rhone-Poulenc  
2 T.W. Alexander Dr.  
RTP, NC 27709  
919-549-2406

Solek, Christopher  
Dow AgroScience  
3828 Latrobe St.  
Los Angeles, CA 90031-1446  
213-223-4017  
csolek@gle.net

St. John, Sara  
AgrEvo  
95 Chestnut Ridge Rd.  
Montvale, NJ 7645

Stejskal, Vaclav  
Research Inst. Crop Prod.  
Dmowska 507  
Prague 6, Czech Republic 16000  
420-236-5228

Steward, V. Bruce  
Bayer Corporation  
104 Davenport Road  
Kennett Square, PA 19348  
610-925-0472

Storey, Greg  
Bayer  
8400 Hawthorn Road  
Kansas City, MO 64120-0013  
816-242-4747

Strickland, Jr., Fred  
Terminix  
5490 Government Blvd.  
Mobile, AL 36693  
334-660-2721

Su, Nan-Yao  
University of Florida  
3205 College Avenue  
Ft. Lauderdale, FL 33314  
954-475-8990  
suny@gnv.ifas.ufl.edu

Suiter, Daniel  
Purdue University  
1158 Entomology Hall  
West Lafayette, IN 47907  
765-494-6314  
dsuiter@entm.purdue.edu

Suoja, Steven  
Univ California Berkeley  
11601 Reilly Ct  
Dublin, CA 94568  
510-828-1190

Suomi, Dan  
WA Dept. of Agric.  
P.O. Box 42589  
Olympia, WA 98504-2589  
360-902-2044  
dsuomi@agr.wa.gov



Tamashiro, Minoru  
Univ of Hawaii  
Department of Entomology  
Honolulu, HI 96822-2271  
808-956-6743  
808-956-2428

Thomas, S. Patricia  
National Institutes of Health  
13 South Drive, MSC 5710, G807  
Bethesda, MD 20892-5710  
301-496-4294  
doc1@box-d.nih.gov

Thomas, Claude  
B&W Sales  
8116 Concord Blvd West  
Jacksonville, FL 32208

Thomas, Jamey  
Dow AgriSciences  
9330 Zionsville Road  
Indianapolis, IN 46268  
317-337-4138  
317-337-4330  
Jdthomas@dowagro.com

Thoms, Ellen  
Dow Agro Sciences  
3225 S. MacDill, #129-258  
Tampa, FL 33629  
813-258-5448  
emthoms@dowagro.com

Toblan, Vern  
Toblan Consulting  
75 Chrome Rd.  
Nottingham, PA 19362

Trimm, Shennan H.  
FMC Specialty Products  
1550 Huntley Cove  
Collierville, TN 38017  
901-854-9662  
shennan\_trimm@fmc.com

Tucker, Jeff  
Entomology Associates, Inc.  
P.O. Box 70375  
Houston, TX 77270  
713-681-9004

Vail, Karen M.  
University of Tennessee  
P.O. Box 1071  
Knoxville, TN 37901-1071  
423-974-7138  
kvail@utk.edu

Valles, Steven  
USDA-ARS  
CMAVE, 1600 SW 23rd Drive  
Gainesville, FL 32608  
352-374-5834  
svalles@gainesville.usda.ufl.edu

Van Gundy, Doug  
Wellmark International  
12200 Denton Drive  
Dallas, TX 75234  
972-888-8531  
doug.vangundy@wellmarkint.com

Vargo, Ed  
University of Texas  
Dept. of Zoology  
Austin, TX 78712

Vogt, J.T.  
Auburn University  
Dept. Entomology  
301 Funchess Hall  
Auburn, AL 36849-5413  
334-844-5006  
jvogt@acesag.auburn.edu

Walgenbach, Paul  
American Cyanamid  
789 Lake Crest Dr.  
El Dorado Hills, CA 95762-3738

Walthall, Mark  
Louisiana State Univ  
104 Sturgis Hall, Agronomy  
Baton Rouge, LA 70803

Wang, Jiasi  
University of Hawaii at Manoa  
Dept. of Entomology  
3050 Maile Way  
Honolulu, HI 96822  
808-956-2462  
jiasi@hawaiiLedu

Wege, Phil  
Zeneca - UK  
Jealotts Hill Research Stn., Bracknell  
**Berks**, United Kingdom 426  
134-441-4299  
philip.wege@ukag.zeneca.com

Weier, Jeff  
Sprague Pest Control  
P.O. Box 2222  
Tacoma, WA 98023  
253-272-4400  
jweier@spraguepest.com

Wheeler, Ron  
SolarisMonsanto  
27201 Cool Water Ranch Road  
Valley Center, CA 92082  
760-749-4601  
ronatd.e.wheeler@monsanto.com

Whitney, Susan P.  
University of Delaware  
Dept. of Entomology &  
Applied Ecology  
Newark, DE 19717-1303  
302-831-8886  
swhitney@udel.edu

Williams, Bob  
Dow AgroSciences  
207 W. Los Angeles Ave.,  
Ste.287  
Moorpark, CA 93021  
805-530-1154  
rewilliams@dowagro.com

Willingham, Keith,  
Western Exterminator Company  
1732 Kaiser Ave.  
Irvine, CA 92614  
714-261-2440

Wiltz, Beverly  
Louisiana State University  
402 Life Sciences Bldg.  
Baton Rouge, LA 70803  
504-388-1830  
wiltz@unix1.sncc.lsu.edu

Woodrow, R. Joseph  
University of Hawaii  
Dept. Entomology  
3050 Maile Way, Rm. 310  
Honolulu, HI 96822  
808-956-2456  
woodrow@hawaH.edu

Wresche, Dee  
Orkin Extermninating Co., Inc.  
2170 Piedmont Rd., NE  
Atlanta, GA 30324  
404-888-2903

Wright, Mark  
Texas A&M University  
Department of Entomology  
College Station, TX 77843  
409-845-5855  
409-845-5926  
mswright@tamu.edu

Wright, Jim  
Clemson University-  
Dept. of Pesticide Regulation  
P.O. Box 21767  
Columbia, SC 29221  
803-772-0766  
803-772-8711  
jwright@clemson.edu

Yates III, Julian R.  
University of Hawaii  
Dept. of Entomology  
3050 Maile Way  
Honolulu, HI 96744  
808-956-6747  
yates@hawaiiLedu

Yoder, Joe  
Novartis Crop Protection  
410 Swing Road  
Greenboro, NC 27409  
336-632-2209  
336-632-2653  
joe.yoder@cp.novartis.com

Young, Stephanie  
University of California  
1134 Blaine Street  
#101 Riverside, CA 92507  
909-684-6510  
kephra1@aol.com

Zeichner, Brian  
U.S. Army  
1207 Tumbridge Rd  
Ento Science Program  
APG, MD 21050

Zungoli, Pat  
Clemson University  
Urban Entomology, Box 340365 Cherry  
Farm  
Clemson, SC 29634-0365  
864-656-3137  
pzngl@clemson.edu

