Structural Pest Control Board
Research Advisory Panel

Dong-Hwan Choe Proposal

"Impact of High Temperature and Chitin Synthesis Inhibitors on Gut Microbial Symbiont Community and Desiccation Tolerance in Western Drywood Termite"

2025

Represented University:
UC Riverside

Funds Requested: $329,970

Term: January 1, 2026 through June 30, 2028

Research and Economic Development
900 University Avenue
200 University Office Building
Riverside, CA 92521

July 30, 2025

Department of Consumer Affairs, Structural Pest Control Board
2005 Evergreen St.
Suite 1500
Sacramento, CA 95815

RE: UCR Kuali PD #3525

On behalf of The Regents of the University of California, we are presenting for your review a request for support of the following proposal:

Principal Investigator:	Dr. Dong-Hwan Choe Entomology Department
Title:	"Impact of High Temperature and Chitin Synthesis Inhibitors on Gut Microbial Symbiont Community and Desiccation Tolerance in Western Drywood Termite"
Support Requested:	$329,970
Period of Support:	January 1, 2026 through June 30, 2028
Type of Request:	New Research Grant

Your favorable consideration of this proposal is greatly appreciated. In the event this proposal is selected to be funded, we are committed to providing the appropriate programmatic and administrative personnel as necessary to the project and we are aware of the sponsoring agency's guidelines.

If additional information is required, please contact the undersigned by phone at (951) 827-3815 or via e-mail at lauren.green@ucr.edu.

Sincerely,

DocuSigned by:
Lauren Green
8FE225D2A7514F5...

Lauren Green
Sr. Contract & Grant Officer
Sponsored Programs Administration

ATTACHMENT 1

REQUIRED ATTACHMENT CHECKLIST

A complete proposal will consist of the items identified on the list below.

Complete this checklist to confirm that all items are contained with your proposal. Place a check mark or "✓" next to each item that you are submitting to the State. For your proposal to be responsive, in addition to your proposal, all required attachments must be returned. This checklist should be returned along with your proposal.

It is essential that the Cost Proposal be complete, thorough, and comply with content sequence requirements. The proposal must be typed and double-spaced on 8½ X 11 paper. All pages shall be consecutively numbered. All elements shall follow the sequence presented on the following checklist:

✓ Check	Attachment #	Attachment Name/Description	Form Provided	Completion Required
V	Attachment 1	Required Attachment Checklist	YES	YES
V	Attachment 2	Cost Proposal/Budget Display Sheets	YES	YES
V	Attachment 3	Budget Narrative Form and Explanation of Costs	YES	YES
V	Attachment 4	Proposer's References	YES	YES
V	Attachment 5	Sample Agreement a) Project Summary and Scope of Work b) Schedule of Deliverables c) Key Personnel d) Authorized Representatives and Notices e) Use of Pre-existing Intellectual Property f) Current & Pending Support g) Third Party Confidential Information (if applicable) h) Budget Justification	YES	YES
V	Attachment 6	Resumes (Curriculum Vitae) for Proposer, Proposer's staff involved in project, and all Subcontractors	NO	YES
V	Attachment 7	Narrative of Research Objectives, as described in Rating/Scoring Criteria	NO	YES
V	Attachment 8	Narrative of Project Direction (Work Plan and Work Schedule), as described in Rating/Scoring Criteria	NO	YES
V	Attachment 9	Narrative of Qualifications, as described in "Minimum Qualifications for Proposers" and Rating/Scoring Criteria	NO	YES
V	Attachment 10	Copy of current business license, professional certificates, or other credentials	NO	YES

ATTACHMENT 2

COST PROPOSAL/BUDGET DISPLAY
RESEARCH PROPOSAL

YEAR 1 – (for first 12 months)

Period of award
(i.e., 1/1/25-12/31/25)
Use separate sheet for each year

Period of award: 01/01/ 2026 – 12/31/2026

Contractor: Dong-Hwan Choe, University of California - Riverside

Project Title/Description: Impact of High Temperature and Chitin Synthesis Inhibitors on Gut Microbial Symbiont Community and Desiccation Tolerance in Western Drywood Termite

Description	Hours	Rate	Total
PERONNEL SERVICES			
1. Postdoctoral Researcher (TBD)	1280	$35.98	$46,049
2. Staff Research Associate (SRA) II	157	$36.26	$5,678
3. Staff Research Associate (SRA) II	140	$30.33	$4,222
		Total Salaries	$55,949
		Total Benefits	$14,530
		Total Personnel Services (A)	$70,479
SUBCONTRACTOR SERVICES			
1. Classification	N/A		
2. Classification			
3. Classification			
		Total Subcontractor Services (B)	
OTHER SERVICES			
1. Classification	N/A		
2. Classification			
3. Classification			
		Total Other Services (C)	
OPERATING EXPENSES			
1. Supplies and Expense			$10,000
2. Travel In-State			$1,000
3. Travel Out-of-State			
4. Equipment			
5. Other Costs (Full 16S Sequencing Service)			$10,000
		Total Operating Expenses (D)	$21,000
Total Personnel and Operating (Add A through D)		$91,479	
Indirect Costs (IDC rate: 30%)		$27,444	
TOTAL COSTS – Year 1 (for the first 12 months)		$118,923	

ATTACHMENT 2, Cont.

COST PROPOSAL/BUDGET DISPLAY
RESEARCH PROPOSAL

YEAR 2 – (for months 13 thru 24)

Period of award
(i.e., 1/1/26-12/31/26)
Use separate sheet for each year

Period of award: 01/01/ 2027 – 12/31/2027

Contractor: Dong-Hwan Choe, University of California - Riverside

Project Title/Description: Impact of High Temperature and Chitin Synthesis Inhibitors on Gut Microbial Symbiont Community and Desiccation Tolerance in Western Drywood Termite

Description	Hours	Rate	Total
PERONNEL SERVICES			
4. Postdoctoral Researcher (TBD)	1920	$37.05	$71,145
5. Staff Research Associate (SRA) II	209	$37.35	$7,798
6. Staff Research Associate (SRA) II	209	$31.24	$6,523
		Total Salaries	$85,466
		Total Benefits	$21,927
		Total Personnel Services (A)	$107,393
SUBCONTRACTOR SERVICES			
4. Classification	N/A		
5. Classification			
6. Classification			
		Total Subcontractor Services (B)	
OTHER SERVICES			
4. Classification	N/A		
5. Classification			
6. Classification			
		Total Other Services (C)	
OPERATING EXPENSES			
6. Supplies and Expense			$10,000
7. Travel In-State			$1,000
8. Travel Out-of-State			
9. Equipment			
10. Other Costs (Full 16S Sequencing Service)			$10,000
		Total Operating Expenses (D)	$21,000
Total Personnel and Operating (Add A through D)		$128,393	
Indirect Costs (IDC rate: 30%)		$38,518	
TOTAL COSTS – Year 1 (for the first 12 months)		$166,911	

ATTACHMENT 2, Cont.

COST PROPOSAL/BUDGET DISPLAY
RESEARCH PROPOSAL

YEAR 3 – (for months 25 thru 36)

Period of award
(i.e., 1/1/27-12/31/27)
Use separate sheet for each year

Period of award: 01/01/ 2028 – 06/30/2028

Contractor: Dong-Hwan Choe, University of California - Riverside

Project Title/Description: Impact of High Temperature and Chitin Synthesis Inhibitors on Gut Microbial Symbiont Community and Desiccation Tolerance in Western Drywood Termite

Description	Hours	Rate	Total
PERONNEL SERVICES			
7. Postdoctoral Researcher (TBD)	640	$38.17	$24,427
8. Staff Research Associate (SRA) II	35	$38.47	$1,339
9. Staff Research Associate (SRA) II	52	$32.18	$1,680
		Total Salaries	$27,446
		Total Benefits	$6,505
		Total Personnel Services (A)	$33,951
SUBCONTRACTOR SERVICES			
7. Classification	N/A		
8. Classification			
9. Classification			
		Total Subcontractor Services (B)	
OTHER SERVICES			
7. Classification	N/A		
8. Classification			
9. Classification			
		Total Other Services (C)	
OPERATING EXPENSES			
11. Supplies and Expense			$0
12. Travel In-State			$0
13. Travel Out-of-State			
14. Equipment			
15. Other Costs (Full 16S Sequencing Service)			$0
		Total Operating Expenses (D)	$0
Total Personnel and Operating (Add A through D)		$33,951	
Indirect Costs (IDC rate: 30%)		$ 10,185	
TOTAL COSTS – Year 1 (for the first 12 months)		$ 44,136	

ATTACHMENT 2, Cont.

COST PROPOSAL/BUDGET DISPLAY
RESEARCH PROPOSAL

COMBINED YEARS – (up to 3 years or 36 months)

Period of award
(i.e., 1/1/26-12/31/28)
Use separate sheet for each year

Period of award: 01/01/ 2026 – 06/30/2028

Contractor: Dong-Hwan Choe, University of California - Riverside

Project Title/Description: Impact of High Temperature and Chitin Synthesis Inhibitors on Gut Microbial Symbiont Community and Desiccation Tolerance in Western Drywood Termite

Description	Hours	Rate	Total
PERONNEL SERVICES			
10. Postdoctoral Researcher (TBD)	3840		$141621
11. Staff Research Associate (SRA) II	401		$14815
12. Staff Research Associate (SRA) II	401		$12,425
		Total Salaries	$168,861
		Total Benefits	$42,962
		Total Personnel Services (A)	$211,823
SUBCONTRACTOR SERVICES			
10. Classification	N/A		
11. Classification			
12. Classification			
		Total Subcontractor Services (B)	
OTHER SERVICES			
10. Classification	N/A		
11. Classification			
12. Classification			
		Total Other Services (C)	
OPERATING EXPENSES			
16. Supplies and Expense			$20,000
17. Travel In-State			$2,000
18. Travel Out-of-State			
19. Equipment			
20. Other Costs (Full 16S Sequencing Service)			$20,000
		Total Operating Expenses (D)	$42,000
Total Personnel and Operating (Add A through D)		$253,823	
Indirect Costs (IDC rate: 30%)		$76,147	
TOTAL COSTS – Year 1 (for the first 12 months)		$329,970	

ATTACHMENT 3,

BUDGET NARRATIVE FORM AND EXPLANATION OF COSTS:

Explain the need for individual staff, budgeted travel, equipment, subcontracts and consultants:
Postdoctoral Researcher (TBD), University of California, Riverside, 100% effort for the 2-year period of the project (for 8 months for year 1, 12 months for year 2, and 4 months for year 3). Will carry out day-to-day tasks described in the proposal on the effect of high temperature on drywood termite physiology, behavior, and survival. Will collect and maintain drywood termites that are necessary for the project, and set up experiments described in the proposal, and collect and analyze the data.

Kathleen Campbell, Staff Research Associate, University of California, Riverside, 10% effort. Will assist Postdoctoral Researcher (TBD) and PI and co-PI to collect and maintain drywood termites that are necessary for the project. If necessary, will also assist Postdoctoral Researcher (TBD) and PI and co-PI to set up experiments described in the proposal, and collect and analyze the data.

Hoeun Park, Staff Research Associate, University of California, Riverside, 10% effort. Will assist Postdoctoral Researcher (TBD) and PI and co-PI to collect and maintain drywood termites that are necessary for the project. If necessary, will also assist Postdoctoral Researcher (TBD) and PI and co-PI to set up experiments described in the proposal, and collect and analyze the data.

Materials and supplies ($20,000) are needed to complete all of the necessary laboratory work, including insect maintenance, bioassays, desiccation tolerance / cuticular permeability study, DNA extractions, and sample collection / shipping.

Travel expense ($2,000 total) is requested to cover the expenses for laboratory truck (Choe laboratory) or personal vehicle use for several 1-day trips within Riverside, CA area for collecting western drywood termites for the proposed research. For most of the time, the postdoctoral researcher (TBD) and one of the Staff Research Associates will be traveling for this. About 10 trips are expected per year for the first 2 years of the project. $100 per trip * 10 * 2 years = $2,000.

Other Direct Costs (ODC) Justification: For gut microbiome investigation (many of them are not culturable in the laboratory), the sequencing of the microbial gene is critical. The sequencing service cost is included in the budget as ODC. The full 16S Sequencing Service including (1) DNA Purification, (2) Library Preparation (16S V3-V4), (3) Pooling and Post-Library QC, (4) Illumina NextSeq® Sequencing (2x300), (5) Bioinformatics Analysis and Support costs approximately $2,500 for 20 samples. We estimate we will need at least 4 sets of samples to be analyzed per year for the first 2 years of the project.

Please explain how the costs were arrived at:
Personnel costs were derived from approved UC Riverside rates for both personnel costs and fringe rates, with a cost-of-living increase built in annually. Supplies were estimated on historical figures from similar projects.
Travel was estimated using the current mileage reimbursement rates, approved by the IRS.

Please explain why the rates are considered reasonable and/or appropriate in your opinion:
Personnel costs were estimated at the UC Riverside's approved rates, by title. These costs are set by the University.
At UC Riverside, we purchase materials, supplies, and other services (gene sequencing) through approved vendors, providing reasonable pricing to the University. Travel was estimated using currently approved federal rates.

Are costs based on industry standard or other basis of measurement? Please explain:
Personnel costs are based on UC Riverside's approved rates by pay title, with the recommended cost of living adjustments. Materials/Supplies are based in industry standards for the University of California system. Travel is based on approved federal reimbursement rates.

ATTACHMENT 4

PROPOSER REFERENCES

1. Please attach three letters of reference on company letterhead.
2. List below three references of similar types of services performed, as described in the description of services, within the last five years. If three references cannot be provided, please explain why on an attached sheet of paper.

REFERENCE 1	
Name of Firm	Rentokil Terminix
Address	305 N Crescent Way, Anaheim, CA 92801
Contact Person	Claudio Salem - DVM - BCE
Telephone Number	800-968-2440
Dates of Service	N/A
Value or Cost of Service	N/A

Brief Description of Service Provided:
Collaboration on a previous project entitled "Development and implementation of the reduced-risk urban IPM strategy to reduce the risk of insecticide runoff in urban settings."

REFERENCE 2	
Name of Firm	GreenTech Heat Solutions
Address	901 S Vía Rodeo, Placentia, CA 92870
Contact Person	Michael Linford
Telephone Number	855-484-2847
Dates of Service	N/A
Value or Cost of Service	N/A

Brief Description of Service Provided:
Collaboration on a previous project entitled "Reducing risks associated with fumigation by improving current heat treatment and localized treatment technologies."

REFERENCE 3	
Name of Firm	IPM4YOU Pest & Termite
Address	9830 Via Leslie, Santee, CA 92071
Contact Person	James Panknin
Telephone Number	844-476-4968
Dates of Service	N/A
Value or Cost of Service	N/A

Brief Description of Service Provided:
Collaboration on a previous project entitled "Baseline assessment for bed bug impact and control, and demonstration of bed bug IPM for multiple-occupancy housing situations in California."

STATE OF CALIFORNIA
STANDARD AGREEMENT
STD 213 (Rev 06/03)

ATTACHMENT 5 – SAMPLE AGREEMENT

AGREEMENT NUMBER	
REGISTRATION NUMBER	

1. This Agreement is entered into between the State Agency and the Contractor named below:

STATE AGENCY'S NAME
Department of Consumer Affairs, Structural Pest Control Board

CONTRACTOR'S NAME
TBD

2. The term of this Agreement is: July 1, 2025 (or upon approval, whichever is later) through **TBD**

3. The maximum amount of this Agreement is: $

4. The parties agree to comply with the terms and conditions of the following exhibits which are by this reference made a part of the Agreement.

Exhibit A – **A7**: A–Scope of Work; A1–Deliverables; A2–Key Personnel; A3–Authorized Representatives; A4–Use of Intellectual Property; A5–Resumes; A6–Current & Pending Support; A7-Third Party Confidential Information (if applicable) page(s)

Exhibit B – B–Budget; B1–Budget Justification; B2– Subawardee Budgets (if applicable); B3–Invoice Elements page(s)

Exhibit C* – University Terms and Conditions UTC-518

Check mark additional Exhibits below, and attach applicable Exhibits or provide internet link:

- ☐ **Exhibit D** – Additional Requirements Associated with Funding Sources page(s)
- ☐ **Exhibit E** – Special Conditions for Security of Confidential Information page(s)
- ☐ **Exhibit F** – Access to State Facilities or Computing Resources page(s)
- ☐ **Exhibit G** – Negotiated Alternate UTC Terms page(s)

Items shown with an Asterisk (*), are hereby incorporated by reference and made part of this agreement as if attached hereto. These documents can be viewed at http://www.dgs.ca.gov/ols/Resources/ModelContractLanguageUniversities.aspx.

IN WITNESS WHEREOF, this Agreement has been executed by the parties hereto.

CONTRACTOR

CONTRACTOR'S NAME *(if other than an individual, state whether a corporation, partnership, etc.)*

BY *(Authorized Signature)* ✍ | DATE SIGNED *(Do not type)*

PRINTED NAME AND TITLE OF PERSON SIGNING

ADDRESS

STATE OF CALIFORNIA

AGENCY NAME
Department of Consumer Affairs, Structural Pest Control Board

BY *(Authorized Signature)* ✍ | DATE SIGNED *(Do not type)*

PRINTED NAME AND TITLE OF PERSON SIGNING

ADDRESS
1625 N. Market Blvd., Suite S-103
Sacramento, CA 95834

California Department of General Services Use Only

Exhibit A – Scope of Work

Project Summary & Scope of Work

☐ Contract ☐ Grant

PI Name: *Dong-Hwan Choe*

Project Title: *Impact of High Temperature and Chitin Synthesis Inhibitors on Gut Microbial Symbiont Community and Desiccation Tolerance in Western Drywood Termite*

Project Summary/Abstract

The western drywood termite, *Incisitermes minor* (Hagen), is one of the most important termite pests in California. Fumigation with sulfuryl fluoride is frequently chosen for whole-structure treatment for this pest. Even though these two control practices have unique advantages (e.g., lower environmental impact, no need to evacuate house for several days, potential residual protection – for localized insecticide injection), their fundamental principles and applications have been largely unchanged over the last century. While most of the research on these two methods has focused on the short-term mortality effect (e.g., immediate mortality within a few days of treatment), our understanding on their long-term impact on colony activity such as feeding and excavation is limited. Through our proposed research, we plan to further improve our understanding on these non-fumigation methods and expand their applicability. Ultimately, our effort may help to increase the adoption of these non-fumigation methods whenever appropriate.

First, we will investigate if the exposure to selected CSIs and the sub-target high temperature (45-47 °C) for 2 h has any impact on termites' feeding / excavating behavior. For CSI treatment, three different compounds will be used in this study: bistrifluron, chlorfluazuron, and noviflumuron. Besides these, other CSIs such as hexaflumuron and novaluron will be also considered. Stock acetone solutions of CSIs will be used to treat a piece of 4 by 2.7 cm balsa wood, providing 0.1 or 0.5% (wt/wt) of the CSI in the wood. Acetone only will be used for the control. One piece of the treated wood will be placed in a plastic Petri dish. A group of 10 - 20 pseudergates will be introduced per dish. The Petri dish will be kept in a humidity chamber kept at 26° C for 3 d. For heat treatment, experimental arenas will be constructed from pieces of Douglas fir to simulate termite galleries in infested structural lumber. Each arena will be consisted of two pieces of wood (1.9 cm height each). To hold the termites, a narrow channel will be routed along the centerline of one piece from each pair. A sheet of clear acrylic (0.2 × 3.8 × 12.7 cm) will be placed over the top of the channel bearing bottom piece of the arena to facilitate observation. In total, 10 - 20 pseudergates will be used per each arena. A GC oven will be used to provide consistent heat treatment. Several chosen temperatures within the range of 45-47 °C will be used for this study (with 2-h treatment time).

The treated termites will be moved to a different container (a 20-ml scintillation vial) with a piece of filter paper with known weight. After a certain period of time, the amount of consumption of the paper will be measured to estimate the level of feeding by the termites. These values will be compared between the treatments and control using GLM or non-parametric methods, such as a Kruskall-Wallis test. Treatments and control will be replicated 10 times.

Secondly, we will investigate the impacts of CSIs and high temperatures on western drywood termite gut microbiome. Hindgut samples will be collected, and the microbiome community will be analyzed (diversity, abundance, etc.) by sequencing the microbial genes in the hindgut samples (16S Amplicon Sequencing). ZymoBIOMICS®-96 MagBead DNA Kit will be used for DNA extraction. The DNA samples will be prepared for targeted sequencing with the Quick-16S™ Plus NGS Library Prep Kit (Primer Set V3-V4). The final library will be sequenced on Illumina® NextSeq 2000™ with a p1 reagent kit (600 cycles). A quantitative real-time PCR will be set up with a standard curve for absolute abundance quantification. Taxa composition plots will be used to illustrate the microbial composition. The taxonomy abundance heatmap with sample clustering will be used to identify patterns of microbial distribution among samples. Alpha diversity and beta diversity values will be used to quantify microbial diversity of the samples. Non-metric multidimensional scaling (nMDS) and permutational analysis of variance (PERMANOVA) will be used to quantify differences among samples and assess statistical significance.

Based on the findings from the second study, we will also include some subsequent investigations. One of the possibilities is testing the effect of presence of nestmates on recovery from the CSI or heat treatment. For example, if the treatment (either CSI or heat treatment) impacted gut microbiome and subsequently termites' feeding (excavating) activity, would they be able to recover from that when other unexposed termites (with normal gut microbiome) are available in the colony to share their gut microbiome through trophallaxis?

Third, we will investigate the impact of CSIs and high temperatures on western drywood termites' desiccation tolerance. For this, cuticular permeability will be calculated and compared between the treated and untreated control termites. Separate groups of live and dead termites will be used to evaluate if there was a difference between physical water loss and physiologically mediated water loss from their bodies. Termites prepared for the dead groups will be killed with ethyl acetate fumes and immediately used for experimentation. The rate of weight loss (as water vapor) over 12 h will be calculated for 10 groups each of 10 live and 10 dead workers/pseudergate. Cuticular permeability (CP) [the amount of water lost (µg) per unit surface area (cm^2) per unit time (h) per unit saturation deficit (mmHg)], which is often used to describe and compare evaporative water loss from body surface of insects and other arthropods, will be calculated using a method reported in Sponsler and Appel (1990) by using the 12-h water loss data. Surface area will be estimated based on the weight (Haggsma et al. 1996), and the saturation deficit will be calculated. CP values will be compared between different treatments using GLM or a non-parametric Kruskal-Wallis test.

Finally, we will investigate the combined impact of CSI and high temperature on feeding activity and long-term survival of western drywood termite colonies. The methods described in the first study (sub-target heat exposure) will be used to house the termite colonies. The method of delivery of CSI and the temperature condition to be used will be determined based on the two earlier experiments. If the wooden arena is used for the experiments, the number of fecal pellets produced will be used as a proxy of feeding activity. Overall survivorship trends (e.g., number of surviving termites) will be compared between control and treatments (e.g., CSI only, heat only, CSI plus heat) with survivorship analyses.

If Third-Party Confidential Information is to be provided by the State:

☐ Performance of the Scope of Work is anticipated to involve use of third-party Confidential Information and is subject to the terms of this Agreement; ***OR***

☐ A separate CNDA between the University and third-party is required by the third-party and is incorporated in this Agreement as Exhibit A7, Third Party Confidential Information.

Scope of Work

Describe the goals and specific objectives of the proposed project and summarize the expected outcomes. If applicable, describe the overall strategy, methodology, and analyses to be used. Include how the data will be collected, analyzed, and interpreted as well as any resource sharing plans as appropriate. Discuss potential problems, alternative strategies, and benchmarks for success anticipated to achieve the goals and objectives.

This information is fully provided in the Attachment 7 (Research Objectives) and Attachment 8 (Project Direction)

Exhibit A1 - Deliverables

SCHEDULE OF DELIVERABLES

List all items that will be delivered to the State under the proposed Scope of Work. Include all reports, including draft reports for State review, and any other Deliverables, if requested by the State and agreed to by the Parties.

If use of any Deliverable is restricted or is anticipated to contain preexisting Intellectual Property with any restricted use, it will be clearly identified in Exhibit A4, Use of Preexisting Intellectual Property.

Unless otherwise directed by the State, the University Principal Investigator shall submit all Deliverables to the State Contract Project Manager, identified in Exhibit A3, Authorized Representatives.

Deliverable	Description	Due Date
Interim progress report	Provide a brief (2-3 pages) written interim progress report to address progress made, findings to date, and problems encountered.	06/30/2026
Interim progress report	Provide a brief (2-3 pages) written interim progress report to address progress made, findings to date, and problems encountered.	12/31/2026
Present a progress report	Present a progress report at one Board Meeting	TBD (2026)
Interim progress report	Provide a brief (2-3 pages) written interim progress report to address progress made, findings to date, and problems encountered.	06/30/2027
Interim progress report	Provide a brief (2-3 pages) written interim progress report to address progress made, findings to date, and problems encountered.	12/31/2027
Present a progress report	Present a progress report at one Board Meeting	TBD (2027)
Final report	Provide a comprehensive written Final Report	09/30/2028
Present a final report	Present a final report at one Board Meeting	TBD
The following Deliverables are subject to Section 19. Copyrights, paragraph B of Exhibit C		

Exhibit A2 – Key Personnel

KEY PERSONNEL

List Key Personnel as defined in the Agreement starting with the PI, by last name, first name followed by Co-PIs. Then list all other Key Personnel in alphabetical order by last name. For each individual listed include his/her name, institutional affiliation, and role on the proposed project. Use additional consecutively numbered pages as necessary.

Last Name, First Name	Institutional Affiliation	Role on Project
PI:		
Choe, Dong-Hwan	*Department of Entomology* *University of California* *Riverside*	As a principal investigator of the project, Choe will be overseeing the project plan, execution, and progress. Choe will be also advising the project team members who will be carrying out the proposed research.
Co-PI(s) – if applicable:		
Lee, Chow-Yang	*Department of Entomology* *University of California* *Riverside*	As a co-PI, Lee will be providing his expertise in termite biology and management for the current project.
Other Key Personnel (if applicable):		
Rust, Michael	*Department of Entomology* *University of California* *Riverside*	As a collaborator, Rust will be providing his expertise in termite biology and management for the current project.
Sutherland, Andrew	*UCCE Alameda County* *UC IPM*	As a collaborator, Sutherland will be providing his expertise in urban IPM as well as utilizing his outreach skills and networks to extend information that will be generated from this project.
Postdoctoral researcher (TBD)	*Department of Entomology* *University of California* *Riverside*	As a postdoctoral researcher in the Choe laboratory, he or she will be carrying out all of the research activities described in the proposal. The postdoctoral researcher will be carrying the experimental design and data collection for the project under the

		guidance of PI (Choe) and other project team members.
Campbell, Kathleen	*Department of Entomology* *University of California* *Riverside*	As a Staff Research Associate, Campbell will assist Postdoctoral Researcher (TBD) and PI to collect and maintain drywood termites that are necessary for the project. If necessary, Campbell will also assist Postdoctoral Researcher (TBD) and PI to set up experiments described in the proposal, and collect and analyze the data.
Park, Hoeun	*Department of Entomology* *University of California* *Riverside*	As a Staff Research Associate, Park will assist Postdoctoral Researcher (TBD) and PI to collect and maintain drywood termites that are necessary for the project. If necessary, Park will also assist Postdoctoral Researcher (TBD) and PI to set up experiments described in the proposal, and collect and analyze the data.

Exhibit A3 – Authorized Representatives

AUTHORIZED REPRESENTATIVES AND NOTICES

The following individuals are the authorized representatives for the State and the University under this Agreement. Any official Notices issued under the terms of this Agreement shall be addressed to the Authorized Official identified below, unless otherwise identified in the Agreement.

State Agency Contacts	**University Contacts**
Agency Name: <Agency Name>	University Name: The Regents of the University of California (UC), Riverside
Contract Project Manager (Technical) Name: <Name> <Title> Address: <Department> <Address> <City,State,Zip> Telephone: <Telephone#> Fax: <Fax#, if available> Email: <EmailAddress>	***Principal Investigator*** Name: Dong-Hwan Choe, Cooperative Extension Specialist / Professor in Urban Entomology Address: Department of Entomology University of California Riverside, CA 92508 Telephone: 951-827-5717 Fax: 951-827-3086 Email: donghwan.choe@ucr.edu Designees to certify invoices under Section 14 of Exhibit C on behalf of PI: N/A
Authorized Official (contract officer) Name: <Name> <Title> Address: <Department> <Address> <City,State,Zip> Telephone: <Telephone#> Fax: <Fax#, if available> Email: <EmailAddress> ***Send notices to (if different):*** Name: <Name> <Title> Address: <Department> <Address> <City,State,Zip> Telephone: <Telephone#> Email: <EmailAddress>	***Authorized Official*** Name: Lauren Green, Principal Contract and Grant Officer Address: Sponsored Programs Administration University of California, Riverside 245 University Office Bldg. Riverside, CA 92521-0217 Telephone: 951-827-3692 Fax: 951-827-4483 Email: lauren.green@ucr.edu ***Send notices to (if different):*** Same as above.
Administrative Contact Name: <Name>	***Administrative Contact*** Name: Lauren Green, Principal Contract and Grant Officer

<Title> Address: <Department> <Address> <City,State,Zip> Telephone: <Telephone#> Fax: <Fax#, if available> Email: <EmailAddress>	Address: Sponsored Programs Administration University of California, Riverside 245 University Office Bldg. Riverside, CA 92521-0217 Telephone: 951-827-3692 Fax: 951-827-4483 Email: lauren.green@ucr.edu
Financial Contact/Accounting Name: <Name> <Title> Address: <Department> <Address> <City,State,Zip> Telephone: <Telephone#> Fax: <Fax#, if available> Email: <EmailAddress>	***Authorized Financial Contact/Invoicing*** Name: Kimberly Gala Post Award Accounting Manager Address: Extramural Funding 900 University Ave. Riverside, CA 92521 Telephone: 951-827-1953 Fax: Email: EMF@UCR.EDU Designees for invoice certification in accordance with Section 14 of Exhibit C on behalf of the Financial Contact: 1. <Name>, <Title>, <EmailAddress> 2. <Name>, <Title>, <EmailAddress> 3. <Name>, <Title>, <EmailAddress>

Exhibit A4 – Use of Intellectual Property

USE OF INTELLECTUAL PROPERTY

If either Party will be using any third-party or pre-existing intellectual property (including, but not limited to data, copyrighted works, known patents, trademarks, service marks and trade secrets) "IP" with restrictions on use, then list all such IP and the nature of the restriction below. If no third-party or pre-existing IP will be used, check "none" in this section.

A. State: Preexisting IP to be provided to the University from the State or a third party for use in the performance in the Scope of Work.

☒ None or ☐ List:

Owner (Name of State Agency or 3rd Party)	Description	Nature of restriction:

B. University: Restrictions in Preexisting IP included in Deliverables identified in Exhibit A1, Deliverables.

☒ None or ☐ List:

Owner (Name of University or 3rd Party)	Description	Nature of restriction:

C. Anticipated restrictions on use of Project Data.

If the University PI anticipates that any of the Project Data generated during the performance of the Scope of Work will have a restriction on use (such as subject identifying information in a data set) then list all such anticipated restrictions below. If there are no restrictions anticipated in the Project Data, then check "None" in this section.

☒ None or ☐ List:

Owner (University or 3rd Party)	Description	Nature of Restriction:

Exhibit A5 - RÉSUMÉ/BIOSKETCH

RÉSUMÉ/BIOSKETCH

Attach Resume/Biosketch for the PI and other Key Personnel listed in Exhibit A2, Key Personnel.

These items are provided as Attachment 6.

Exhibit A6 – Current & Pending Support

CURRENT & PENDING SUPPORT

University will provide current & pending support information for Key Personnel identified in Exhibit A2 at time of proposal and upon request from State agency. The "Proposed Project" is this application that is submitted to the State. Add pages as needed.

PI: Dong-Hwan Choe

Status (currently active or pending approval)	Award # (if available)	Source (name of the sponsor)	Project Title	Start Date	End Date
Proposed Project	N/A	Structural Pest Control Board	Impact of High Temperature and Chitin Synthesis Inhibitors on Gut Microbial Symbiont Community and Desiccation Tolerance in Western Drywood Termite	Jan 2026	Jun 2028
PENDING	N/A (TBD)	California Department of Pesticide Regulation	Reinventing Integrated Pest Management System for Wood Destroying Insects	2025 (exact date TBD)	Jun 2027

Chow-Yang Lee

Status	Award #	Source	Project Title	Start Date	End Date
Proposed Project	N/A	Structural Pest Control Board	Impact of High Temperature and Chitin Synthesis Inhibitors on Gut Microbial Symbiont Community and Desiccation Tolerance in Western Drywood Termite	Jan 2026	Jun 2028
PENDING	N/A (TBD)	California Department of Pesticide Regulation	Improvement of silica gel dust and dust mixtures as safer alternatives, and development of a lethal harborage for German cockroach control	2025 (exact date TBD)	Jun 2028
CURRENT		Syngenta Crop Protection, NC	Resistance monitoring of an isoxazoline compound in *Blattella germanica* in United States	Jan 2022	Dec 2025
CURRENT		California Celery Research Advisory Board	Insecticide resistance of celery pests focusing on the Lygus bug, Lygus hesperus	Oct 2022	Sep 2025

Andrew Sutherland

Status	Award #	Source	Project Title	Start Date	End Date
Proposed Project	N/A	Structural Pest Control Board	Impact of High Temperature and Chitin Synthesis Inhibitors on Gut Microbial Symbiont Community and Desiccation Tolerance in Western Drywood Termite	Jan 2026	Jun 2028
CURRENT	4400008437	County of Santa Clara	Educational IPM Video Production for the County of Santa Clara	11/18/22	12/31/25
PENDING	TBD	Structural Pest Control Board	Areawide IPM for nuisance ants and cockroaches in residential neighborhoods	01/01/26	06/30/27

Michael Rust

Status (currently active or pending approval)	Award # (if available)	Source (name of the sponsor)	Project Title	Start Date	End Date
Proposed Project	N/A	Structural Pest Control Board	Impact of High Temperature and Chitin Synthesis Inhibitors on Gut Microbial Symbiont Community and Desiccation Tolerance in Western Drywood Termite	Jan 2026	Jun 2028
PENDING	N/A (TBD)	California Department of Pesticide Regulation	Reinventing Integrated Pest Management System for Wood Destroying Insects	2025 (exact date TBD)	Jun 2027

Kathleen Campbell

Status	Award #	Source	Project Title	Start Date	End Date
Proposed Project	N/A	Structural Pest Control Board	Impact of High Temperature and Chitin Synthesis Inhibitors on Gut Microbial Symbiont Community and Desiccation Tolerance in Western Drywood Termite	Jan 2026	Jun 2028
PENDING	N/A (TBD)	California Department of Pesticide Regulation	Reinventing Integrated Pest Management System for Wood Destroying Insects	2025 (exact date TBD)	Jun 2027

Hoeun Park

Status	Award #	Source	Project Title	Start Date	End Date
Proposed Project	N/A	Structural Pest Control Board	Impact of High Temperature and Chitin Synthesis Inhibitors on Gut Microbial Symbiont Community and Desiccation Tolerance in Western Drywood Termite	Jan 2026	Jun 2028
PENDING	N/A (TBD)	California Department of Pesticide Regulation	Reinventing Integrated Pest Management System for Wood Destroying Insects	2025 (exact date TBD)	Jun 2027

Exhibit A7

Third Party Confidential Information

Confidential Nondisclosure Agreement

(Identified in Exhibit A, Scope of Work – will be incorporated, if applicable)

If the Scope of Work requires the provision of third party confidential information to either the State or the Universities, then any requirement of the third party in the use and disposition of the confidential information will be listed below. The third party may require a separate Confidential Nondisclosure Agreement (CNDA) as a requirement to use the confidential information. Any CNDA will be identified in this Exhibit A7.

Not applicable for this proposal.

EXHIBIT B

BUDGET FOR PROJECT PERIOD

(Cost Proposal/Budget Display from selected proposer will be inserted here)

EXHIBIT B-1

BUDGET JUSTIFICATION

The Budget Justification will include the following items in this format.

Personnel

Name. *Starting with the Principal Investigator list the names of all known personnel who will be involved on the project for each year of the proposed project period. Include all collaborating investigators, individuals in training, technical and support staff or include as "to be determined" (TBD).*

Dong-Hwan Choe, PI
Chow-Yang Lee, Co-PI
Michael Rust
Andrew Sutherland
Postdoctoral Researcher (TBD)
Kathleen Campbell
Hoeun Park

Role on Project. *For all personnel by name, position, function, and a percentage level of effort (as appropriate), including "to-be-determined" positions.*

Dong-Hwan Choe, Cooperative Extension Specialist / Professor in Urban Entomology, University of California, Riverside. 3% effort in-kind, no salary requested. Will serve as the PI during the entire project period, and will develop experimental designs, coordinate with co-PI and other project members, and provide academic oversight and guidance.

Chow-Yang Lee, Professor & Endowed Presidential Chair in Urban Entomology, University of California, Riverside. 1% effort in-kind, no salary requested. Will serve as the co-PI during the entire project period, collaborating with the PI, Choe.

Michael Rust, Distinguished Professor of Entomology, Emeritus, University of California, Riverside. 1% effort in-kind, no salary requested. Will serve as a collaborator during the entire project period, providing advice and useful insights for the PI and co-PI.

Andrew Sutherland, Cooperative Extension Urban IPM Advisor, University of California (UCCE Alameda County & UC IPM). 1% effort in-kind, no salary requested. Will serve as a collaborator during the entire project period, collaborating with the PI, Choe. The role of Sutherland in this project will be assisting in disseminating the research findings to pest management industry and other parties that are involved in urban IPM in California.

Postdoctoral Researcher (TBD), University of California, Riverside, 100% effort for the 2-year period of the project (for 8 months for year 1, 12 months for year 2, and 4 months for year 3). Will carry out day-to-day tasks described in the proposal on the effect of high temperature on drywood termite physiology, behavior, and survival. Will collect and maintain drywood termites that are necessary for the project, and set up experiments described in the proposal, and collect and analyze the data.

Kathleen Campbell, Staff Research Associate, University of California, Riverside, 10% effort. Will assist Postdoctoral Researcher (TBD) and PI and co-PI to collect and maintain drywood termites that are necessary for the project. If necessary, will also assist Postdoctoral Researcher (TBD) and PI and co-PI to set up experiments described in the proposal, and collect and analyze the data.

Hoeun Park, Staff Research Associate, University of California, Riverside, 10% effort. Will assist Postdoctoral Researcher (TBD) and PI and co-PI to collect and maintain drywood termites that are necessary for the project. If necessary, will also

assist Postdoctoral Researcher (TBD) and PI and co-PI to set up experiments described in the proposal, and collect and analyze the data.

Salary. *For all personnel, including "to-be-determined" positions, list the salary per year and the total salary. Additionally, note any in-kind salary contributions.*

Dong-Hwan Choe – Year 1 - $0; in-kind; Year 2 - $0; in-kind; Year 3 - $0; in-kind; Total: $0; in-kind

Chow-Yang Lee – Year 1 - $0; in-kind; Year 2 - $0; in-kind; Year 3 - $0; in-kind; Total: $0; in-kind

Michael Rust – Year 1 - $0; in-kind; Year 2 - $0; in-kind; Year 3 - $0; in-kind; Total: $0; in-kind

Andrew Sutherland – Year 1 - $0; in-kind; Year 2 - $0; in-kind; Year 3 - $0; in-kind; Total: $0; in-kind

Postdoctoral Researcher (TBD) – Year 1 - $46,049; Year 2 - $71,145; Year 3 - $24,427; Total: $141,621

Kathleen Campbell – Year 1 - $5,678; Year 2 - $7,798; Year 3 - $1,339; Total: $ 14,815

Hoeun Park – Year 1 - $4,222; Year 2 – $ 6,523; Year 3 - $1,680; Total: $ 12,425

Fringe Benefits.
In accordance with University policy, explain the costs included in the budgeted fringe benefit percentages used, which could include tuition/fee remission for qualifying personnel to the extent that such costs are provided for by University policy, to estimate the fringe benefit expenses on Exhibit B.

Dong-Hwan Choe – Year 1 - $0; in-kind; Year 2 - $0; in-kind; Year 3 - $0; in-kind; Total: $0; in-kind

Chow-Yang Lee – Year 1 - $0; in-kind; Year 2 - $0; in-kind; Year 3 - $0; in-kind; Total: $0; in-kind

Michael Rust – Year 1 - $0; in-kind; Year 2 - $0; in-kind; Year 3 - $0; in-kind; Total: $0; in-kind

Andrew Sutherland – Year 1 - $0; in-kind; Year 2 - $0; in-kind; Year 3 - $0; in-kind; Total: $0; in-kind

Postdoctoral Researcher (TBD) – Year 1 - $ 9,186; Year 2 - $ 14,193; Year 3 - $ 4,873; Total: $ 28,253

Kathleen Campbell – Year 1 - $ 3,049; Year 2 - $ 4,188; Year 3 - $ 719; Total: $ 7,956

Hoeun Park – Year 1 - $ 2,294; Year 2 – $3,545; Year 3 - $ 913; Total: $ 6,753

Total Personnel Costs.

Yearly Salary Totals

Year 1 - $ 55,949; Year 2 - $ 85,466; Year 3 - $ 27,446; Total: $168,861

Yearly Fringe Benefits Totals

Year 1 - $ 14,530; Year 2 - $ 21,927; Year 3 - $ 6,505; Total: $ 42,961

Yearly Personnel Totals

Year 1 - $70,479; Year 2 - $107,393; Year 3 - $ 33,951; Total: $211,822

Travel

Itemize all travel requests separately by trip and justify in Exhibit B1, in accordance with University travel guidelines. Provide the purpose, destination, travelers (name or position/role), and duration of each trip. Include detail on airfare, lodging and mileage expenses, if applicable. Should the application include a request for travel outside of the state of California, justify the need for those out-of-state trips separately and completely.

TRIP #1

Trip Occurs in year 1

Origin: Riverside Area

Destination: Riverside Area, Orange County, San Bernardino, San Diego Area

Duration (number of days and number of nights): 1 day per trip

Personnel Names: Postdoctoral Researcher, SRAs

Purpose: Termite collection

Total Cost per Trip: $100

Number of Trip Occurrences: 10

Trip #1 Total: $1,000

TRIP #2

Trip Occurs in year 2

Origin: Riverside Area

Destination: Riverside Area, Orange County, San Bernardino, San Diego Area

Duration (number of days and number of nights): 1 day per trip

Personnel Names:

Personnel Names: Postdoctoral Researcher, SRAs

Purpose: Termite collection

Total Cost per Trip: $100

Number of Trip Occurrences: 10

Trip #2 Total: $1,000

Total Travel Costs.

Year 1 - $1,000; Year 2 - $1,000; Yeat 3 - $0; Total: $2,000

Materials and Supplies

Itemize materials supplies in separate categories. Include a complete justification of the project's need for these items. Theft sensitive equipment (under $5,000) must be justified and tracked separately in accordance with State Contracting Manual Section 7.29.
Materials and Supplies Justification: Materials and supplies needed to complete all

all of the necessary laboratory work, including insect maintenance, bioassays, desiccation tolerance / cuticular permeability study, DNA extractions, and sample collection / shipping. **See detailed list of Materials and Supplies in the Main Budget Excel document.**

Total Materials and Supplies Costs

Year 1 - $10,000; Year 2 - $10,000; Year 3 - $0; Total: $20,000

Equipment

List each item of equipment (greater than or equal to $5,000 with a useful life of more than one year) with amount requested separately and justify each.

N/A

Consultant Costs

Consultants are individuals/organizations who provide expert advisory or other services for brief or limited periods and do not provide a percentage of effort to the project or program. Consultants are not involved in the scientific or technical direction of the project as a whole.

Provide the names and organizational affiliations of all consultants. Describe the services to be performed, and include the number of days of anticipated consultation, the expected rate of compensation, travel, per diem, and other related costs.

N/A

Subawardee (Consortium/Subrecipient) Costs

Each participating consortium organization must submit a separate detailed budget for every year in the project period in Exhibit B2 Subcontracts. Include a complete justification for the need for any subawardee listed in the application.

N/A

Other Direct Costs

Itemize any other expenses by category and cost. Specifically justify costs that may typically be treated as indirect costs. For example, if insurance, telecommunication, or IT costs are charged as a direct expense, explain reason and methodology.

Full 16S Sequencing Service

ODC 1 – Year 1 - $10,000; Year 2 - $10,000; Year 3 - $0; Total: $20,000
Subject to Indirect Costs (IDC)

Other Direct Costs (ODC) Justification: For gut microbiome investigation the sequencing is critical. The sequencing service cost is included in the budget as ODC. The full 16S Sequencing Service including (1) DNA Purification, (2) Library Preparation (16S V3-V4), (3) Pooling and Post-Library QC, (4) Illumina NextSeq® Sequencing (2x300), (5) Bioinformatics Analysis and Support costs approximately $2,500 for 20 samples. We estimate we will need at least 4 sets of samples to be analyzed per year.

Rent

If the Scope of Work will be performed in an off-campus facility rented from a third party for a specific project or projects, then rent may be charged as a direct expense to the award.

N/A

Indirect (F&A) Costs

Indirect costs are calculated in accordance with the budgeted indirect cost rate in Exhibit B.

$ 76,147 (IDC rate: 30%)

Exhibit B2 – Subawardee Budgets

Budget Pertaining to Subawardee(s) (when applicable)

Subawardee Name:

Principal Investigator (Last, First):

Exhibit B2

COMPOSITE SUBAWARDEE BUDGET FOR ENTIRE PROPOSED PROJECT PERIOD
07/01/2025 to 06/30/2028

From: / To: / BUDGET CATEGORY		7/1/2025 6/30/2026 Year 1	7/1/2026 6/30/2027 Year 2	7/1/2027 6/30/2028 Year 3	TOTAL
PERSONNEL: *Salary and fringe benefits.*		$0	$0	$0	$0
TRAVEL		$0	$0	$0	$0
MATERIALS & SUPPLIES		$0	$0	$0	$0
EQUIPMENT		$0	$0	$0	$0
CONSULTANT		$0	$0	$0	$0
SUBRECIPIENT		$0	$0	$0	$0
OTHER DIRECT COSTS (ODC)	*Subject to IDC Calc*				
ODC #1	*Y*	$0	$0	$0	$0
ODC #2	*Y*	$0	$0	$0	$0
ODC #3	*Y*	$0	$0	$0	$0
ODC #4	*Y*	$0	$0	$0	$0
ODC #5	*Y*	$0	$0	$0	$0
ODC #6	*Y*	$0	$0	$0	$0
TOTAL DIRECT COSTS		**$0**	**$0**	**$0**	**$0**
Indirect (F&A) Costs					
Rate	F&A Base *MTDC **	*$0*	*$0*	*$0*	*$0*
		$0	**$0**	**$0**	**$0**
TOTAL COSTS PER YEAR		**$0**	**$0**	**$0**	
TOTAL COSTS FOR PROPOSED PROJECT PERIOD					**$0**

* MTDC = Modified Total Direct Cost

JUSTIFICATION. *See Exhibit B1 - Follow the budget justification instructions.*

Project Period Budget Flexibility (lesser of % or Amount)

Prior approval required for budget changes between approved budget categories above the thresholds identified.

% **10.00%**

or

Amount *$10,000*

Exhibit B3 – Invoice Elements

Invoice and Detailed Transaction Ledger Elements

In accordance with Section 14 of Exhibit C – Payment and Invoicing, the invoice, summary report and/or transaction/payroll ledger shall be certified by the University's Financial Contact and the PI (or their respective designees).

Summary Invoice – includes either on the invoice or in a separate summary document – by approved budget category (Exhibit B) – expenditures for the invoice period, approved budget, cumulative expenditures and budget balance available[1]

- Personnel
- Equipment
- Travel
- Subawardee – Consultants
- Subawardee – Subcontract/Subrecipients
- Materials & Supplies
- Other Direct Costs
    - TOTAL DIRECT COSTS (if available from system)
- Indirect Costs
    - TOTAL

Detailed transaction ledger and/or payroll ledger for the invoice period [2]

- Univ Fund OR Agency Award # (to connect to invoice summary)
- Invoice/Report Period (matching invoice summary)
- GL Account/Object Code
- Doc Type (or subledger reference)
- Transaction Reference#
- Transaction Description, Vendor and/or Employee Name
- Transaction Posting Date
- Time Worked
- Transaction Amount

[1] If this information is not on the invoice or summary attachment, it may be included in a detailed transaction ledger.

[2] For salaries and wages, these elements are anticipated to be included in the detailed transaction ledger. If all elements are not contained in the transaction ledger, then a separate payroll ledger may be provided with the required elements.

Exhibit C – University Terms and Conditions

CMA (AB20) State/University Model Agreement Terms & Conditions 518

https://www.ucop.edu/research-policy-analysis-coordination/_files/cma_documents/exhibit-c_utc-220_feb_2020.pdf

Attachment 6. Curriculum Vitae

BIOGRAPHICAL SKETCH

NAME	POSITION TITLE
Choe, Dong-Hwan	Professor / Extension Specialist in Urban Entomology

EDUCATION/TRAINING

INSTITUTION AND LOCATION	DEGREE	YEAR(s)	FIELD OF STUDY
Department of Entomology University of California, Riverside, CA, USA	PhD	2009	Entomology
Department of Entomology University of California, Riverside, CA, USA	MS	2005	Entomology
Department of Agricultural Biology Korea University, Seoul, Korea	BA	2002	Agriculture

Experience and Research Focus

My research focuses on three major areas: urban entomology, insect behavior, and chemical ecology. In particular, my research has focused on exploring innate and learned behaviors of economically or environmentally important insect species to develop more effective integrated pest management (IPM) programs. I use manipulative laboratory studies to investigate how the behaviors of pest insects can be exploited to improve management and to develop novel management techniques. I also test the feasibility of these new techniques in real-world conditions. I draw upon my expertise in behavioral ecology, experimental design, chemical ecology and analytical chemistry to illuminate the biology of target insects, and to inform the design of new approaches for control. In addition to the bioassays involving chemistry, physiology, behavior, and toxicology, the effort to incorporate the behavioral information of target species into the working IPM program often requires extensive design, manufacturing, and testing of devices in the field.

Positions and Employment

7/2023 - current	CE Specialist and Professor Entomology / UC Riverside
7/2018 – 6/2023	Associate CE Specialist and Associate Professor Entomology / UC Riverside
11/2011 – 6/2018	Assistant CE Specialist and Assistant Professor Entomology / UC Riverside
11/2009 - 10/2011	Postdoctoral Researcher Environmental Science, Policy, and Management / UC Berkeley

Memberships, Honors and Awards

09/2016 - Present	Member. Pi Chi Omega.
01/2005 - Present	Member. Entomological Society of America.
2022	Award for Excellence in Extension, Entomological Society of America, Pacific Branch (PB ESA).
2020	Medical, Urban, and Veterinary Entomology Award. Entomological Society of America, Pacific Branch (PB ESA).
2016	Scientific Teaching Fellow. 2016 Summer Institute on Scientific Teaching for Undergraduate STEM Education.
2013 - 2016	Early Career Chair in Urban Entomology. UCR.

Presentations (selected since 2020)

02/2024	Biology of Termite and UCR Research Update, Target Specialty Product Workshop, Cerritos, CA.
02/2024	Low-impact management for urban pest ants: Two biorational approaches. Pest Insight webinar (organized by Dr. Siavash Taravati). Online.
11/2023	Controlling Argentine ants and fire ants & personal safety. Agricultural Operations, UC Riverside, Riverside, CA.
09/2023	Biodegradable boric acid hydrogel baits for the control of Argentine ant: Case studies in citrus orchard and grape vineyard. Ant Workshop (organized by David Havilland). Temecula, CA.
02/2023	Museum Pests and Their Management. Invited lecture for UCLA Information Studies (Dr. Ellen Pearlstein), Los Angeles, CA.

11/2022 The use of an attractant may improve localized insecticide treatments targeting the western drywood termite, *Incisitermes minor*. Entomological Society of America. Entomological Society of America. Vancouver, Canada.

08/2022 Evaluation of an artificial sweetener as a potential bait toxicant and an insecticide synergist against German cockroaches. CA Department of Pesticide Regulation Pest Management Advisory Committee (PMAC) Meeting. Online.

08/2022 A sustainable boric acid liquid bait delivery system for the management of pest ants in agricultural settings. CA Department of Pesticide Regulation Pest Management Advisory Committee (PMAC) Meeting. Online.

04/2022 The use of an attractant may improve localized insecticide treatments targeting the western drywood termite, *Incisitermes minor*. Pacific Branch Meeting of Entomological Society of America. Santa Rosa, CA.

02/2022 Drywood Termite Biology. PCOC / UC Berkeley Termite Academy. Online.

11/2021 Reducing Risks Associated with Fumigation by Improving Current Heat Treatment and Localized Treatment Technologies. CA DPR Pest Management Advisory Committee (PMAC) Meeting. California Department of Pesticide Regulation (CA DPR). Online.

11/2021 Biology of ants and their management (+UCR research update). Orange County PCOC (Pest Control Operators of California) Meeting. OC PCOC. Online.

11/2021 Delivering boric acid bait via Alginate Hydrogel: field studies with Argentine ants (Hymenoptera: Formicidae). Annual Meeting of Entomological Society of America. Entomological Society of America. Online.

09/2021 Biology of Ants and Their Management. CAPCA 2021 Urban Pest Management Seminar. CAPCA (California Association of Pest Control Advisers). Escondido, CA.

06/2021 Know Your Ants and How to Manage Them. Master Gardener workshop. UCCE Riverside County Master Gardener Program. Online.

05/2021 Developing an effective baiting strategy for yellowjacket management. Small Winegrowers Association California Meeting. Small Winegrowers Association California. Online.

03/2021 Solving current and evolving problems in urban pest management: Argentine ant case studies. Monthly Meetings of the San Francisco IPM Technical Advisory Committee (SF IPM TAC). SF IPM TAC. Online.

03/2021 Update on bed bug research & management. AzPPO (Arizona Pest Professionals Organization) 2021 Great Western Conference. AzPPO. Online.

02/2021 Drywood Termite Biology. Termite Academy 2021. Pest Control Operators California (PCOC) / University of California – Berkeley. Online.

12/2020 UC Riverside Research Update: Advances in Pheromone Research and Novel Detection Methods. Global Bed Bug Summit 2020. National Pest Management Association. Online.

11/2020 The use of an essential oil adjuvant to improve the efficacy of heat treatments targeting the western drywood termite. Annual Meeting of Entomological Society of America. Entomological Society of America. Online.

11/2020 Reduced-risk methods still need to be efficacious – field tests with pheromone and hydrogel. Annual Meeting of Entomological Society of America. Entomological Society of America. Online.

11/2020 Evaluation of an attractant to improve localized insecticide treatments targeting the western drywood termite, *Incisitermes minor*. Annual Meeting of Entomological Society of America. Entomological Society of America. Online.

10/2020 Ants - Nuisance Pests in and Around Buildings. Insects in the Built Environment. HalfMoon Education (https://halfmoonseminars.org). Online.

09/2020 Updates on Formosan subterranean termite infestation in Southern California. Orange County PCOC (Pest Control Operators of California) Meeting. OC PCOC. Online.

03/2020 Reduced-risk IPM strategies for Argentine ant control (2019 field study). Pyrethroids and Water Quality Training. UC IPM. Santa Clarita, CA.

Publications (selected since 2020)

Le, B., K. Campbell, H. Park, S.-P. Tseng, R. Pandey, G. S. Simmons, R.Henderson, C. Gispert, M. K. Rust, C.-Y. Lee, R. Karimzadeh, Y.-L. Park, and D.-H. Choe. 2024. Field Evaluations of Biodegradable Boric Acid Hydrogel Baits for the Control of Argentine Ants: Promising Results in Vineyards and Citrus Orchards. California Agriculture, June. https://doi.org/10.3733/001c.120496

Poulos, N. A, C.-Y. Lee, M. K. Rust, and D.-H. Choe. 2024. Potential use of pinenes to improve localized insecticide injections targeting the western drywood termite (Blattodea: Kalotermitidae). J. Econ. Entomol. 117: 1628–1635. https://doi.org/10.1093/jee/toae101

Lee, S.-H, D.-H. Choe, M. K. Rust, and C.-Y. Lee. 2024. Oral toxicity of an artificial sweetener sucralose on the German cockroach (Blattodea: Ectobiidae) and its impact on water balance and gut microbiome. J. Econ. Entomol. 117: 268–279. https://doi.org/10.1093/jee/toad206

Rust, M. K., C.-Y. Lee, H. E. Park, K. Campbell, D.-H. Choe, M. Sorensen, A. Sutherland, C. Hubble, B. Nobua-Behrmann, J. Kabashima, S.-P. Tseng, and L. Post. 2023. The potential of fluralaner as a bait toxicant to control pest yellowjackets in California. Insects. 14, 311.

Le, B., H. Park, K. Campbell, M. K. Rust, C.-Y. Lee, and D.-H. Choe. 2023. Laboratory evaluations of biodegradable boric acid hydrogel baits for the control of Argentine ant(Hymenoptera: Formicidae). J. Econ. Ent. 116: 643–647.

Dery, M., and D.-H. Choe. 2023. Effect of bed bug (Hemiptera: Cimicidae) aldehydes on efficacy of fungal biopesticides. J. Econ. Entomol. 116: 40–46.

Dery, M., Dinh, B., Budd, R., & Choe, D.-H. 2022. Wash-off potential of pyrethroids after use of total release fogger products. Science of The Total Environment, 847, 157340. https://doi.org/10.1016/j.scitotenv.2022.157340 (Refereed)

Tseng, S.-P., Taravati, S., Choe, D.-H., Rust, M. K., & Lee, C.-Y. 2022. Genetic Evidence for Multiple Invasions of *Coptotermes formosanus* (Blattodea: Rhinotermitidae) in California. Journal of Economic Entomology, 115(4), 1251–1256. https://doi.org/10.1093/jee/toac104

Lee, S.-H., Choe, D.-H., Scharf, M. E., Rust, M. K., & Lee, C.-Y. 2022. Combined metabolic and target-site resistance mechanisms confer fipronil and deltamethrin resistance in field-collected German cockroaches (Blattodea: Ectobiidae). Pesticide Biochemistry and Physiology, 184, 105123. https://doi.org/10.1016/j.pestbp.2022.105123

Lee, S.-H., Choe, D.-H., Rust, M. K., & Lee, C.-Y. 2021. Reduced Susceptibility Towards Commercial Bait Insecticides in Field German Cockroach (Blattodea: Ectobiidae) Populations from California. Journal of Economic Entomology. https://doi.org/10.1093/jee/toab244

Dery, M., C.-Y. Lee, and D.-H. Choe. 2021.Differential responses to aldehyde pheromone blends in two bed bug species (Heteroptera: Cimicidae). Chemoecology. 31: 397–403.

Choe, D.-H., J.-W. Tay, K. Campbell, H. Park, L. Greenberg, and M. K. Rust. 2021. Development and demonstration of low-impact IPM strategy to control Argentine ants (Hymenoptera: Formicidae) in urban residential settings. J. Econ. Entomol. 114: 1752–1757.

Lee, S.-H., D.-H. Choe, and C.-Y. Lee. 2021. The impact of artificial sweeteners on insects. J. Econ. Entomol. 114: 1-13.

Dery, M., K. Arriola, C.-Y. Lee, and D.-H. Choe. 2020. Ontogenesis of aldehyde pheromones in two synanthropic bed bug species (Heteroptera: Cimicidae). Insects. 11(11), 759.

Ko, A. and D.-H. Choe. 2020. Development of a lateral flow test for bed bug detection. Sci. Rep. 10: 13376. https://doi.org/10.1038/s41598-020-70200-0

Tay, J.-W., D.-H. Choe, A. Mulchandani, and M. K. Rust. 2020. Hydrogels: from controlled release to a new bait delivery for insect pest management. J. Econ. Entomol. 113: 2061–2068.

Perry, D. T. and D.-H. Choe. 2020. Volatile essential oils can be used to improve the efficacy of heat treatments targeting the western drywood termite: evidence from simulated whole house heat treatment trials. J. Econ. Entomol. 113: 2448-2457.

McCalla, K., J.-W. Tay, A. Mulchandani, D.-H. Choe, M. S. Hoddle. 2020. Biodegradable alginate hydrogel bait delivery system effectively controls high-density populations of Argentine ant in commercial citrus. J. Pest. Sci. 93:1031–1042.

Perry, D. T. and D.-H. Choe. 2020. Volatile essential oils can be used to improve the efficacy of heat treatments targeting the western drywood termite: evidence from a laboratory study. J. Econ. Entomol. 113: 1373-1381.

NAME: **Chow-Yang Lee**

AFFILIATION: Department of Entomology, University of California, Riverside, CA 92521.

POSITION TITLE: Professor & Endowed Presidential Chair in Urban Entomology

EDUCATION/TRAINING

INSTITUTION AND LOCATION	DEGREE *(if applicable)*	Start Date MM/YYYY	Completion Date MM/YYYY	FIELD OF STUDY
Universiti Sains Malaysia, Penang	B.Sc. Ph.D.	07/1989 09/1993	08/1993 09/1996	Biology (Zoology) Entomology (Insect Toxicology)
Entomological Society of America	Board Certified Entomologist (BCE)		07/1997	Specialization: Urban & Industrial (No. B2452)

Personal Statement

My research direction centers around the behavioral, ecological, and physiological adaptations of urban insect pests, especially understanding how these adaptations help them to thrive in the urban environment and their biological trade-offs. I am also interested in the roles of human activities and propagule pressure in invasion history of urban insect pests. Using the research findings obtained, my students and I design, evaluate, and integrate multiple management tactics to provide a system-level approach towards urban pest management. Our recent research activities focus on morphological and biological traits, insecticide resistance and its underlying mechanisms, endosymbiont roles, phylogenetics, population genetics, and environmental physiology of bed bugs, termites, cockroaches, pest ants, and mosquitoes.

PROFESSIONAL APPOINTMENTS (1996–Present)

2019–present:	Professor & Endowed Presidential Chair in Urban Entomology, University of California, Riverside (75% Professor of Entomology, 25% Entomologist)
2006–2019:	Professor of Entomology, School of Biological Sciences, Universiti Sains Malaysia (50% Research, 50% Teaching)
2010:	Acting Dean of Life Science, Universiti Sains Malaysia.
2002–2006:	Associate Professor of Entomology, School of Biological Sciences, Universiti Sains Malaysia (50% Research, 50% Teaching)
1996–2002:	Lecturer, School of Biological Sciences, Universiti Sains Malaysia (50% Research, 50% Teaching)

SELECTED HONORS AND AWARDS (2000 – 2024)

2024	Fellow, Entomological Society of America
2022	Recognition Award in Medical, Urban & Veterinary Entomology, Entomological Society of America
2022	Distinguished Achievement Award in Urban Entomology, National Conference on Urban Entomology
2021	Medical, Urban & Veterinary Entomol. Award, Pacific Branch, Entomological Society of America
2012	Top Research Scientists Malaysia Award, awarded by the Academy of Sciences, Malaysia.
2008	The Outstanding Young Malaysian Awards 2008, Junior Chamber International Malaysia.
2003	MSPTM Silver Medal 2003, Malaysian Society of Parasitology and Tropical Medicine.
2002	Fulbright Scholarship 2002, Malaysian-American Commission of Educational Exchange.
2000	National Young Scientist Award 2000. Ministry of Science and Technology, Malaysia.

PUBLICATIONS AND MENTORING (1993 – 2024)

Total peer-reviewed journal articles:	229
Total edited books:	7
Total books:	4
Total book chapters:	38
Total number of graduate students mentored:	17 Ph.D. and 32 M.S.
Present number of graduate students mentored:	4 Ph.D., 1 M.S.
Total number of postdoctoral scholars mentored:	6

PUBLICATIONS OVER THE LAST 2 YEARS (2023 – 2024)

Hellemans S, MM Rocha, M Wang, JR Arias, DK Aanen, A-G Bagnères, A Buček, TF Carrijo, T Chouvenc, C Cuezzo, JP Constantini, R Constantino, F Dedeine, J Deligne, P Eggleton, TA Evans, C Jouault, R Hanus, MC Harrison, M Harry, G Josens, CM Kalleshwaraswamy, E Kaymak, J Korb, CY Lee, F Legendre, HF Li, N Lo, T Lu, K Matsuura, K Maekawa, DP McMahon, N Mizumoto, DE Oliveira, M Poulsen, D Sillam-Dussès, NY Su, G Tokuda, EL Vargo, JL Ware, J Šobotník, RH Scheffrahn, E Cancello, Y Roisin, MS Engel, T Bourguignon. 2024. Genomic data provide insights into the classification of extant termites. *Nature Communications* 15:6724.

Le B, K Campbell, H Park, S-P Tseng, R Pandey, GS Simmons, R Henderson, C Gispert, MK Rust, CY Lee, R Karimzadeh, YL Park, DH Choe. 2024. Field evaluations of biodegradable boric acid hydrogel baits for the control of Argentine ants: Promising results in vineyards and citrus orchards. *California Agriculture*. Doi: 10.3733/001c.120496.

Poulos NA, CY Lee, MK Rust, DH Choe. 2024. Potential use of pinenes to improve localized insecticide injections targeting the western drywood termite (Blattodea: Kalotermitidae). *Journal of Economic Entomology* 117: 1628–1635.

Lee SH, J So, GS Kund, JY Lum, E Trinh, EL Ta, R Chungsawat, DH Choe, DL Cox, MK Rust, CY Lee. 2024. Toxicity of isocycloseram, an isooxazoline insecticide, against laboratory and field-collected German cockroaches (Blattodea: Ectobiidae). *Journal of Economic Entomology* 117: 1086–1094.

Tseng SP, SH Lee, DH Choe, CY Lee. 2024. Overexpression of cytochrome P450 gene CYP6K1 is associated with pyrethroid resistance in German cockroaches (Blattodea: Ectobiidae) from California. *Journal of Economic Entomology* 117: 1071–1076.

Lee CY, ME Scharf. 2024. Editorial overview: Insecticide resistance mechanisms — from behavior and physiology to microbiome science. Current Opinion in Insect Science 63: 101204.*Current Opinion in Insect Science* 63: 101204.

Scharf ME, CY Lee. 2024. Insecticide resistance in social insects: assumptions, realities, and possibilities. *Current Opinion in Insect Science* 62: 101161.

Lee SH, DH Choe, MK Rust, CY Lee. 2024. Oral toxicity of an artificial sweetener sucralose on the German cockroach (Blattodea: Ectobiidae) and its impact on water balance and gut microbiome. *Journal of Economic Entomology* 117: 268–279.

Rust MK, CY Lee, GW Bennett, WH Robinson. 2024. The emergence and sustainability of urban entomology. *Annual Review of Entomology* 69: 59–79.

Kamimura Y, CY Lee. 2023. Subcortical life, evolution of flattened body, and constrained mating posture in the earwig Platylabia major (Insecta: Dermaptera: "Anisolabididae"). *PLoS One* 18: e0293701.

Tseng SP, LJ Nelson, CW Hubble, AM Sutherland, MI Haverty, CY Lee. 2023. Phylogenetic analyses of *Reticulitermes* (Blattodea: Rhinotermitidae) from California and other western states: multiple genes confirm undescribed species identified by cuticular hydrocarbons. *Journal of Economic Entomology* 116: 2135–2145.

Principato S, A Romero, CY Lee, K Campbell, DH Choe, C Schal, Z DeVries. 2023. Histamine excretion in common indoor and hematophagous arthropods. *Journal of Medical Entomology* 60: 1269–1277.

Tisgratog R, C Panyafaeng, SH Lee, MK Rust, CY Lee. 2023. Insecticide resistance and its potential mechanisms in field-collected German cockroaches (Blattodea: Ectobiidae) from Thailand. *Journal of Economic Entomology* 116: 1321–1328.

So J, DH Choe, MK Rust, JT Trumble & CY Lee. 2023. The impact of selenium on insects. *Journal of Economic Entomology* 116:1041–1062.

Rust MK, CY Lee, H Park, K Campbell, DH Choe, M Sorenson, A Sutherland, C Hubble, B Nobua-Behremann, J Kabashima, SP Tseng, L Post. The potential of fluralaner as a bait toxicant to control pest yellowjackets in California. *Insects* 14: 311. https://doi.org/ 10.3390/insects14040311

Le B, H Park, K Campbell, MK Rust, CY Lee & DH Choe. 2023. Laboratory evaluations of biodegradable boric acid hydrogel baits for the control of Argentine ant (Hymenoptera: Formicidae). *Journal of Economic Entomology* 116:643– 647.

Kamimura Y, CY Lee, J Yamasako, M Nishikawa. 2023. Identification and reproductive isolation of Euborellia species (Insecta, Dermaptera, Anisolabididae) from East and Southeast Asia. *Zookeys* 1146:115–134.

Doggett SL & CY Lee. 2023. Historical and contemporary control options against bed bugs, *Cimex* spp. *Annual Review of Entomology* 68: 169–190.

Lum JY, MC Chiu, SP Tseng, CCS Yang & CY Lee. 2023. Anthropogenic influence on the distribution of the longlegged ant (Hymenoptera: Formicidae). *Journal of Economic Entomology* 116: 520–528.

Tan MK, J Duncan, RH Abdul Wahab, CY Lee, R Japir, AYC Chung, JB Baroga-Barbecho, SA Yap, F Montealegre-Z. 2023. The calling songs of some katydids (Orthoptera: Tettigonioidea) from the tropical forests of Southeast
Asia. *Journal of Orthoptera Research* 32: 1–24.

Tseng SP, H Darras, PW Hsu, T Yoshimura, CY Lee, JK Wetterer, L Keller & CCS Yang. 2023. Genetic analysis reveals the putative native range and widespread double-clonal reproduction in the invasive longhorn crazy ant. *Molecular Ecology* 32: 1020–1033.

Leong XY, CY Lee, G Veera Singham, AC Shu-Chien, R Naylor, A Naylor, DM Miller, MM Wilson, DG Lilly, & SL Doggett. 2023. Evaluation of a pyrethroid-impregnated mattress liner on multiple international strains of *Cimex lectularius* and *Cimex hemipterus*. *Journal of Economic Entomology* 116:19–28.

Kai D, SL Doggett & CY Lee. 2022. Performance of pyrethroid-neonicotinoid mixture formulations against field- collected strains of the tropical bed bug (Hemiptera: Cimicidae) on different substrates. *Journal of Economic Entomology* 116: 29–39.

Lee CY, C Wang & NY Su. 2023. Perspective on biology and management of bed bugs: Introduction. *Journal of Economic Entomology* 116:1–4.

Michael K. Rust - Curriculum Vitae

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Academic Record

M.A. University of Kansas, Lawrence, Kansas. Entomology. 1973. Thesis title: "The Mecoptera of India and Adjacent Regions." Major Professor - Dr. George W. Byers.

Ph.D. University of Kansas, Lawrence, Kansas, 1975. Dissertation title: "An Ethometric Analysis of Sex Pheromone and Associated Behavior in the American Cockroach, *Periplaneta americana*." Major Professor - Dr. William J. Bell.

Positions

Distinguished Professor and Entomologist, Department of Entomology and the Graduate Division, University of California, Riverside — 2012-present

Distinguished Professor and Entomologist, Department of Entomology, University of California, Riverside — 2011-2012

Professor and Entomologist, Department of Entomology University of California, Riverside — 2003-2010

Professor and Entomologist, Department of Entomology University of California, Riverside. Director for Center for Exotic Pest Research; Associate Director University of California Integrated Pest Management Program — 2000-2003

Professor and Entomologist, Department of Entomology University of California, Riverside — 1997-1999

Associate Professor and Associate Entomologist and Head, Division of Economic Entomology, University of California, Riverside — 1983-1986

Assistant Professor and Assistant Entomologist, Department of Entomology, University of California, Riverside — 1975-1982

Professional Societies - Entomological Society of America, Pi Chi Omega, AAAS

Honors and Awards

Orkin Research Award - 1990, 1995, 1997
Outstanding Urban Entomologist Award Recipient; Pacific Branch Entomology Society of America, 1990, 1991 and 1993
Distinguished Achievement Award in Urban Entomology, Entomology Society of America, 1993
W.W. Woodworth Award; Pacific Branch, Entomology Society of America 1994
1994 Excellence in Entomology Award - California Association, American Registry of Professional Entomologists
Book of Professional Services Award, Pi Chi Omega, 1995
UC Presidential Scholar in Entomology, 1999, 2000
Mallis Recognition Award, National Conference on Urban Entomology, 2000
Pest Control Technology's 25 Most Influential People in the Industry, 2000
Fellow of the Entomological Society of America, 2001
Fellow of American Association for the Advancement of Science, 2002
PCT/Zeneca Leadership Award 2002
Pest Control Hall of Fame 2007
Entomological Society of America Recognition Award in Entomology, Pacific Branch 2008
Lifetime Achievement Award – Association of Applied IPM Ecologists 2009
IPM Team Award 2010, Pacific Branch of the Entomological Society of America
IPM Team Award 2010, National Entomological Society of America

Recent Relevant Publications

Tay, J.-W, D.-H. Choe, A. Mulchandani, and M.K. Rust. 2020. Hydrogels: from controlled release to a new bait delivery for insect pest management. J. Econ. Entomol. 11: 2061-6068.

Wang, C., C.-Y. Lee, and M K. Rust. 2021. Biology and Management of the German cockroach. CSIRO, Clayton South, Australia. 308 pp.

Appel, A.G., and M.K. Rust. 2021. Management using baits. In: Biology and Management of the German Cockroach (Wang, C., C.-Y. Lee, M.K. Rust, eds.). CSIRO, Clayton South Australia. pp. 213-230.

Lee, C.-Y., and M.K. Rust. 2021. Chemical control methods. In: Biology and Management of the German Cockroach (Wang, C., C.-Y. Lee, M.K. Rust, eds.). CSIRO, Clayton South Australia. pp. 165-212.

Rust, M.K. 2021. Alternative control measures. In: Biology and Management of the German Cockroach (Wang, C., C.-Y. Lee, M.K. Rust, eds.). CSIRO, Clayton South Australia. pp. 257-268

Lee, S.-H., D.-H. Choe, M.K. Rust, and C.-Y Lee, 2022. Reduced susceptibility towards commercial bait insecticides in field German cockroach (Blattodea: Ectobiidae) populations from California. J. Econ. Entomol. 115: 259-265.

Lee, S.-H., D.-H. Choe, M.E. Scharf, M.K. Rust, and C.-Y. Lee. 2022. Combined metabolic and target-site resistance confer fipronil and deltamethrin resistance in field-collected German cockroaches (Blattodea: Ectobiidae). Pest. Biochem. Physiol. 184. Doi.org/10/1016/j./pestbp.2022. 105123.

Benning, L., H. Park, K. Campbell, M.K. Rust, C.-Y. Lee, and D.-H. Choe. 2023. Laboratory evaluations of biodegradable boric acid hydrogel baits for the control of Argentine ant (Hymenoptera: Formicidae). J. Econ. Entomol. 116: 643-647.

So, J., Choe, D.-H., Rust, M.K., Trumble, J.T., and Lee, C.-Y. 2023. The impact of selenium on insects. J. Econ. Entomol. 116: 1041-1062.

Tisgratog, R., C. Panyafeang, S.-H. Lee, M.K. Rust, and C.-Y. Lee. 2023. Insecticide resistance and its potential mechanisms in field-collected German cockroaches (Blattodea: Ectobiidae) from Thailand. J. Econ. Entomol. 116: 1321-1328.

Lee, S.-H., D.-H. Choe, M.K. Rust, C.-Y. Lee. 2024. Oral toxicity of artificial sweetener sucralose on the German cockroach (Blattodea: Ectobiidae) and its impact on water balance and microbiome. J. Econ. Entomol. Vol. 117: 268-279.

Lee, S.-H., J. So, G.S. Kund, J.Y. Lum, E. Trinh, E.L. Ta, R. Chungsawat, D.-H. Choe, D. L. Cox, M.K. Rust, C.-Y. Lee. 2024. Toxicity of isocycloseram, an isoxazoline insecticide, against laboratory and field-collected German cockroaches (Blattodea: Ectobiidae). J. Econ. Entomol.

Poulos, N.A., C.-Y. Lee, M.K. Rust, D.-H. Choe. 2024. Potential use of pinenes to improve localized insecticide injections targeting the western drywood termite (Blattode: Kalotermitidae. J. Econ. Entomol. 10.193/jee/toae 101.

Curriculum Vitae: Andrew M. Sutherland

Education

Ph.D. Entomology; June 2009; University of California, Davis
M.S. Horticulture and Agronomy; June 2005; University of California, Davis
B.S. Environmental Horticulture; December 2001; University of Florida

Licenses and Certifications

- Board Certified Entomologist (BCE), in Urban & Industrial Entomology and Plant-Related Entomology, certified by the Entomological Society of America, since July 2012
- Qualified Applicator's License (QAL), in Category J: Demonstration and Research, licensed by the California Department of Pesticide Regulation, since June 2012

Current Employment:

- ***SF Bay Area Urban Integrated Pest Management Advisor*, University of California**
- University of California Statewide Integrated Pest Management Program, Division of Agriculture and Natural Resources (UC IPM, UC ANR)
- April 2012 to present, 100% extension appointment
- Programmatic web site: https://ucanr.edu/sites/urbanIPM/

Selected Peer-Reviewed Publications (during the previous three years)

- Chen, J. T.-C., Nelson, L., Rugman-Jones, P.F., Tseng, S.-P., **Sutherland, A.M.**, Choe, D.-H., Haverty, M.I., Lee, C.-Y. 2025 Description of a new species of subterranean termite in the genus Reticulitermes (Blattodea: Heterotermitidae) from southern California, Annals of the Entomological Society of America, 2025;, saaf019, https://doi.org/10.1093/aesa/saaf019
- Bustamante, J., Jr., Liu, P., Campbell, K., **Sutherland, A.M.**, Choe, D.-H., Loudon, C. 2025. A novel leaf-derived trapping material is more effective at capturing common bed bugs (Hemiptera: Cimicidae) than selected commercial monitoring devices. Insects 2025, 16, 362. https://doi.org/10.3390/insects16040362
- Tseng, S-P., Nelson, L.J., Hubble, C.W., **Sutherland, A.M.**, Haverty, M.I., Lee, C-Y. 2023. Phylogenetic analyses of Reticulitermes (Blattodea: Rhinotermitidae) from California and other western states: multiple genes confirm undescribed species identified by cuticular hydrocarbons. Journal of Economic Entomology 116(6), 2135 – 2145; https://doi.org/10.1093/jee/toad182
- Rust, M.K., Lee, C-Y., Park, H.E., Campbell, K., Choe, D-H., Sorensen, M., **Sutherland, A.**, Hubble, C., Nobua-Behrmann, B., Kabashima, J., Tseng, S-P., Post, L. 2023. The potential of fluralaner as a bait toxicant to control pest yellowjackets in California. Insects 14(4), 311; https://www.mdpi.com/2075-4450/14/4/311
- **Sutherland, A.M**.; Hubble, C.; Barber, M. 2022. Installation season may significantly impact time required for subterranean termites to find and feed on in-ground baits. Insects 13(5), 445; https://doi.org/10.3390/insects13050445

Patents

1. McCabe, K.J., Wingo, R.M., Haarmann, T.K., **Sutherland, A.M.**, Gubler, W.D. US Patent #9210914: 'Method for training honeybees to respond to olfactory stimuli', Issued 12/15/2015.

Selected Curriculum and Educational Products

- Taravati, S., Haver, D.L., **Sutherland, A.M.** 2023. *Pest Notes: Hiring a Pest Control Company.* UC ANR Publication 74125 (revised), published August 2023: https://ipm.ucanr.edu/PMG/PESTNOTES/pn74125.html
- *Integrated Pest Management*, 2022. Initial training for UCCE Master Gardener trainees, video-based module with embedded quizzes, group exercises, and homework: https://drive.google.com/drive/folders/1-fXk1Nodg1N3QVMRkqE2k1P36YfnNhVL. March 2022.
- *Recognize, restrict, and report bed bugs*, 2020. State-funded online training program and interactive educational "game" for residents within California's multi-unit rental housing environments: https://www.stopbedbugs.org/. March 2020.
- *Integrated Pest Management Toolkit for Family Child Care Homes,* UCSF California Childcare Health Program, UC IPM, California Department Pesticide Regulation, 2016. In-person & online curriculum: http://cchp.ucsf.edu/content/family-child-care-homes
- *Providing IPM services to schools and child care centers*, Bradman, A., **Sutherland, A.M.**, 2015. Online CE curriculum hosted by UC IPM: http://ipm.ucanr.edu/training/index.html

Authored Grant Proposals Awarded (last five years)

- County of Santa Clara, sponsored contract ($180,000; *Educational video production to support IPM education and evaluation*; December 2023 – ongoing)
- California Department of Pesticide Regulation (CDPR), Pest Management Research Program ($165,721; *Biting Mites in Homes and Structures*; July 2022 – June 2025)
- CDPR, Pest Management Alliance Program ($91,563, *Development of an interactive training facility for pest management professionals*, October 2020 – June 2023)
- CDPR, Pest Management Research Program ($56,913, *First investigations into the biology and management of an invasive cockroach species*, July 2020– June 2023)

Leadership and Committee Service

- UC ANR Associate Editor (Pest Management – Urban), September 2013 – present
- Contra Costa County's IPM Advisory Committee, November 2015 – June 2022, January 2024 - present
- UC ANR Strategic Initiative Advisory Panel (Endemic and Invasive Pests and Diseases) July 2019 – December 2023
- Entomological Society of America: Certification Board, Dec 2013 – Dec 2023
- UC ANR Master Gardener Program: Statewide Steering Committee, July 2013 – June 2022
- UC ANR Pest Management Program Team leader, April 2015 – September 2018
- California's Structural Pest Control Board (Department of Consumer Affairs): Continuing Education Committee, voting member, July 2014 – June 2016

Kathleen Campbell
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EDUCATION

M.A. in Biology, 1995, UC Riverside, Thesis title: A model of persistence of two parasitoids of the California red scale system. Thesis advisor: Leonard Nunney
B.S. in Biology, 1991, UC Riverside

EXPERIENCE

From 1995 to present**:** Entomology Department at the University of California Riverside

1995 to 1998 – Laboratory Assistant for Richard Redak
Participate in arthropod field surveys for the endangered California gnatcatcher.
Identify and curate non-ant hymenoptera to family and organizational taxonomic unit.
Participate in surveys for the presence of Quino checkerspot butterfly.

1998 to 2003 – Staff Research Associate (SRA) for Timothy Paine and Jocelyn Millar
Rear parasitoid wasp natural enemies of eucalyptus pests (wood-boring and leaf-feeding).
Conduct wasp releases for control purposes in Southern California and the East Bay.
Conduct lab and field experiments on the *Phoracantha* beetle – *Avetienella* wasp system.

2003 to 2011 SRA for Richard Redak
Conduct arthropod field surveys for the endangered Blunt-nosed leopard lizard.
Conduct arthropod field surveys at Joshua Tree National Park for edge effects.
Identify and curate non-ant hymenoptera to family and organizational taxonomic unit.
Conduct field trials of pesticide residue effects on Glassy-winged sharpshooter egg masses.

2011 to present SRA for Dong-Hwan Choe
Rear pests of the urban environment, especially Argentine ants, common bed bugs.
Conduct field research for controlling the Western yellowjacket in suburban settings.
Conduct field and lab research to control Argentine ants and common bed bugs.
Conduct lab research on tropical bed bugs and brown widow spider egg sacs.
Conduct field research using hydrogel bait and different toxicants for Argentine ant control.

Certification

California Department of Pesticide Regulation issued QAC (Qualified Applicator Certificate)
Three categories held: A. Residential, Industrial, and Institutional
D. Plant Agriculture
J. Research and Demonstration

PUBLICATIONS

Le, B., K. Campbell, H. Park, S.-P. Tseng, R. Pandey, G. S. Simmons, R.Henderson, C. Gispert, M. K. Rust, C.-Y. Lee, R. Karimzadeh, Y.-L. Park, and D.-H. Choe. 2024. Field Evaluations of Biodegradable Boric Acid Hydrogel Baits for the Control of Argentine Ants: Promising Results in Vineyards and Citrus Orchards. California Agriculture, June. https://doi.org/10.3733/001c.120496 (Supplementary Material) (accepted on May 6, 2024)

Principato, S., A. Romero, C.-Y. Lee, K. Campbell, D.-H. Choe, C. Schal, and Z. DeVries. 2023. Histamine excretion in common indoor and hematophagous arthropods. Journal of Medical Entomology, tjad103, https://doi.org/10.1093/jme/tjad103

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Choe, D.-H., J.-W. Tay, K. Campbell, H. Park, L. Greenberg, and M. K. Rust. 2021. Development and demonstration of low impact IPM strategy to control Argentine ants (Hymenoptera: Formicidae) in urban residential settings. J. Econ. Entomol. 114: 1752-1757.

<u>Publications in Trade/Specialty Magazines:</u>

Choe, D.-H., E. Paysen, L. Greenberg, K. Campbell, and M. Rust. 2019. A closer look: Argentine ant control. Pest Control Technology. October issue: 131, 132, 134, 135.

CONFERENCE TALK

"The use of attractants for western yellowjacket IPM"
Symposium: Novel Techniques in Urban IPM on Wednesday, September 28, 2016
For the 25th International Congress of Entomology in Orlando, Florida, USA

PATENT

Title: Development of pheromone assisted techniques to improve efficacy of insecticide sprays targeting urban pest ant species.
Co-inventors: Dong-Hwan Choe and Kathleen Campbell
Patent publication number: WO 2014039950 A1
Application number: PCT/US2013/058720
US patent application number: 14/426,899

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Education

Master of Science in Applied Behavior Analysis
National University, 2022 – 2023

Bachelor of Science in Biology (Emphasis: Biomedical Sciences)
La Sierra University, 2013 – 2016

Bachelor of Arts in Media & Cultural Studies
University of California, Riverside, 2010 – 2015

Professional Positions

Staff Research Associate 2
Department of Entomology, University of California, Riverside, 2022 – Present
- Responsible for maintaining and rearing laboratory insect colonies.
- Conducted research on urban entomology, focusing on pest control for Western yellowjackets, Argentine ants, termites, and cockroaches.
- Supported field and lab research, prepared biodegradable hydrogel bait, and assisted in organizing conferences and workshops
- Data management and outreach for IPM adoption and alliance formation projects.

Staff Research Associate I
Department of Entomology, University of California, Riverside, 2018 – 2022
- Managed lab insect colonies, including cockroaches, Argentine ants, common bedbugs, and fleas.
- Conducted research on urban pest control solutions for Western yellowjackets, Argentine ants, and cockroaches.
- Participated in insecticide testing, arena construction, and device development for data collection.
- Supported field and lab research, prepared biodegradable hydrogel bait, and assisted in organizing conference.

Undergraduate Research Assistant
Department of Entomology, University of California, Riverside, 2013 – 2017
- Assisted in maintaining bedbug and Argentine ant colonies.
- Engaged in pest control experiments using synthetic volatiles and performed dissections of bed bug glandular pockets.

Research & Work Experience

University of California, Riverside
2023 – Present
- Collaborators: Dr. Michael Rust, Dr. Dong-Hwan Choe, Dr. Chow Yang Lee
- Investigated pest control methods for Western yellowjackets, Argentine ants, and cockroaches.
- Collaborated and conduct field research using biodegradable hydrogel bait with pheromone adjuvant and different toxicants for Argentine Ant control.
- Support in conducting field and lab research on various research projects between labs (e.g., termite monitoring, common bed bugs, etc.).
- Assisted in continuing education workshops and conferences.

2018 – 2023
- Collaborator: Dr. Michael Rust
- Focused on urban pest control research for fleas, cockroaches, and Western yellowjackets.
- Managed preparation of insecticide solutions and built testing environments for data collection.
- Laboratory testing through preparation of insecticide solutions, construction of testing arenas and devices for data collection.

2016 – 2018
- Collaborators: Dr. Dong Hwan Choe, Dr. Jia-Wei Tay
- Developed and tested biodegradable hydrogel bait formulations using alginate and sucrose-pesticide mixtures.
- Researched sugar preferences in Argentine ants.
- Maintaining and rearing of laboratory insect colonies, specifically bedbugs and Argentine ants.

2015 – 2016
- Collaborators: Dr. Dong Hwan Choe, Dr. Christiane Weirauch, Alexander Knyshov, Claudia Vo
- Utilized microtome for bed bug cross-sections and dissected glandular pockets for research.
- Maintaining and rearing of laboratory insect colonies, specifically bedbugs and Argentine ants.

Publications

Choe, D.-H., Park, H., Vo, C., Knyshov, A. (2016). Chemically mediated arrestment of the bed bug, *Cimex lectularius*, by volatiles associated with exuviae of conspecifics. *PLOS ONE 11* (7). https://doi.org/10.1371/journal.pone.0159520

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Le, B., Park, H., Campbell, K., Rust, M. K., Lee, C. Y., & Choe, D. H. (2023). Laboratory evaluations of biodegradable boric acid hydrogel baits for the control of Argentine ant (Hymenoptera: Formicidae). *Journal of economic entomology*, *116*(2), 643–647. https://doi.org/10.1093/jee/toad037

Rust, M. K., Lee, C.-Y., Park, H. E., Campbell, K., Choe, D.-H., Sorensen, M., Sutherland, A., et al. (2023). The Potential of Fluralaner as a Bait Toxicant to Control Pest Yellowjackets in California. *Insects*, *14*(4), 311. MDPI AG. Retrieved from http://dx.doi.org/10.3390/insects14040311

Le, B., Campbell, K., Park, H., Tseng, S.-P., Pandey, R., Simmons, G. S., Henderson, R., Gispert, C., Rust, M. K., Lee, C.-Y., Karimzadeh, R., Park, Y.-L., & Choe, D.-H. (2024). Field evaluations of biodegradable boric acid hydrogel baits for the control of Argentine ants: Promising results in vineyards and citrus orchards. *California Agriculture*, *78*(2). https://doi.org/10.3733/001c.120496

Honors and Awards

Carl Strom/Western Exterminator Company Scholarship in Urban Entomology
Awarded: March 2015

Licenses and Certifications

Qualified Applicator Certificate
QAC#: 153342
Issued: January 2024 | Expiration: December 2025

Skills & Technical Expertise

- Insect rearing and colony maintenance (Argentine ants, cockroaches, fleas, bedbugs, and termites)
- Urban pest control research methods
- Insecticide testing and data analysis
- Biodegradable bait formulation
- Field and laboratory research coordination
- Conference and workshop organization
- Data management and scientific outreach

ATTACHMENT 7. RESEARCH OBJECTIVES

A. Background

Surveys of inspection reports reveal that drywood termites have a significant economic impact in California. One of the most common drywood termites found in California, western drywood termite, *Incisitermes minor* (Hagen), has the greatest economic importance. According to Lewis (2003) and other references therein, drywood termite infestation rates in California can be as high as 36-47% of the structures inspected. Control of drywood termite infestations is predominantly done by making localized insecticide injection (e.g., drill and inject), but use of whole structure fumigation with sulfuryl fluoride is common. In fact, according to the California Department of Pesticide Regulation (CDPR), sulfuryl fluoride is the single most widely used active ingredient in structural pest control. For example, in 2018, sulfuryl fluoride use makes more than 70% of entire pesticide use in California for structural pest control (based on active ingredient). Gaeta et al. (2024) showed California emits the highest amount of sulfuryl fluoride in the US. Sulfuryl fluoride is recognized as "Toxic Air Contaminant (TAC)" as well as "acute inhalation toxicity category I pesticide" by CDPR. Sulfuryl fluoride is also a potent greenhouse gas. Therefore, it is important to use fumigation only when it is needed (e.g., drywood termite infestation is widespread, infested wood members are inaccessible for local treatment options, use of heat treatment is not practical due to the presence of heat sensitive items).

Reliance on the fumigation for drywood termites might, at least in part, due to real estate transactions and perceived concerns over missed infestations (i.e., undetected drywood termites). However, it is important to note that fumigation does not provide residual protection from future infestation by drywood termites. Integrated Pest Management (IPM) for drywood termites, consisting of homeowner engagement and education, preventive measures, regular inspection, integrated use of nonchemical tactics and reduced-risk materials, and program evaluation, will be the ideal approach, and it will also help to minimize risk to public health and the environment. To make drywood termite

management more sustainable, it would be essential to increase general public's awareness on the importance of vigilant and ongoing "management", over "elimination or eradication" effort at the end of long ignorance of the pest issue. One of the important steps in this effort would be increasing our understanding on existing non-fumigation treatment options.

Common non-fumigation options for the drywood termites include localized insecticide injection and heat treatment. The localized insecticide injection can be an effective control tool when the infestation is restricted to a small group of boards that are accessible. Heat treatment is a nonchemical method which is useful to treat the areas where the localized insecticide injection is not practical (e.g., entire attic). Even though accurate detection of drywood termite infestation is one of the important requirements for these options, it is important to note that most of the control effort of drywood termites starts with discovery of some sort of termite activity anyway (e.g., fecal pellets, swarming activity, etc.). Furthermore, some recent technological advancements in termite detection and temperature monitoring have aided the non-fumigation options. Considering unique advantages of these two non-fumigation approaches (e.g., lower environmental impact, no need to evacuate house for several days, potential residual protection – for localized insecticide injection), it is important to further improve our understanding on them and expand their applicability.

B. Existing knowledge

For the localized insecticide injection, our recent laboratory research indicates that chitin synthesis inhibitors (CSIs) introduced into termite gallery have a great potential as an effective management tool for drywood termites. Due to their non-repellency, slow action, and excellent transfer, CSIs are used as an essential tool for subterranean termite baiting. Since injection sites can be numerous and many of them might be located indoor for drywood termite control, low mammalian toxicity of CSIs is among the compelling advantages over other existing chemistries (most of them are neurotoxic) that are currently

registered for localized injection. Even though our research suggests a promising possibility to utilize CSIs for localized treatment of drywood termites, one may worry that the insects would continue damaging the structure before they are killed. However, based on our preliminary observations, exposure to CSI appears to have a rather quick (within a week after exposure) effects on the drywood termites such as shrinkage of their body and reduced feeding / excavation activity (Fig. 1). This observation indicated that CSIs may impact feeding behavior in the drywood termites. We hypothesize the sub-target high temperature impact the termites' gut symbionts that are essential in digesting wood, consequently shutting down their feeding activity (being unable to process wood). The drywood termites require their symbiotic gut microorganisms to digest wood (lignocellulose) and obtain important nutrients (Arora et al. 2022). However, Shamsuri and Ab Majid (2024) reported that feeding on CSI bait resulted in an alteration in the abundance of some microbial gut symbionts in some termite species. Another immediate impact of CSI on drywood termite might be connected to their reduced desiccation tolerance. Exposure to a CSI is known to decrease drought tolerance in some arthropods with chitinous exoskeleton (Xie et al. 2024).

Fig. 1. Termites exposed to 0.1% bistrifluron treatment within an experimental arena. The surviving termites show a significant shrinkage in their abdomens, and the production of fecal pellets is very low. The blue color comes from a dye, which was included in the bistrifluron formulation for visualization.

Even if it has been scientifically demonstrated that the high temperature (target temperature of about 50 °C inside of the termite gallery and hold it for an hour) can be effective in controlling drywood termites, we recognized lack of information on the impact of sub-target high temperature (between 45-47 °C) on termite biology and survival. Since it is not always practical to achieve the 50 °C target temperature in every corner of the infested structure (due to the presence of heat sinks and 'difficult-to-heat' areas), it is important to understand the impact of the sub-target high temperature on drywood termite colonies. Perry et al. (2020) showed that exposure to 45-47 °C for 2 h caused a delayed (or

latent) mortality in western drywood termites over 2-10 days (Fig. 2). One of the apparent behavioral changes of the termite colonies exposed to the sub-target temperature was lack of feeding activity. Also, many of these latent mortalities were characterized by the slow shrinkage of termites' abdomen (as if they are drying out) over time. These observations led us to hypothesize that exposure to 45-47 °C does not kill the termite immediately, but rather impacts the drywood termite' other essential biological functions (e.g., symbiotic gut microorganisms or cuticular desiccation barrier), eventually making the termites unable to survive. Exposure to high temperature (35 °C) for an extended amount of time is known to impact richness and relative abundance of microbial gut symbionts in a subterranean termite species (Arango et al. 2021). In many terrestrial arthropods, it is known that the waterproofing cuticular wax loses its impermeability to water abruptly at a particular temperature and that "transition" temperature vary between difference species (Beament 1959).

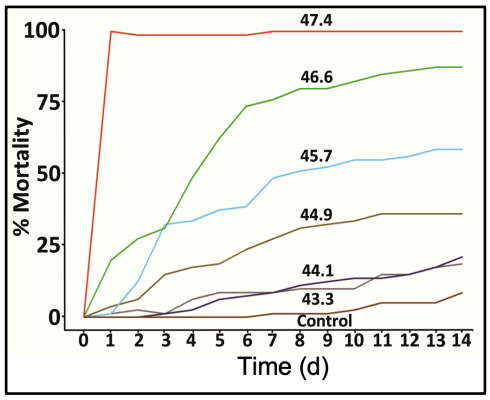

Fig. 2. Cumulative mortality (%) of *I. minor* (western drywood termite) from heat only trials. The numbers above the line indicate the temperature condition (°C) for the 2-hour treatment.

C. Gaps filled by the proposed research

The western drywood termite, *Incisitermes minor* (Hagen), is one of the most economically important termite pests in California. Fumigation with sulfuryl fluoride is frequently chosen for whole-structure treatment for this pest. Non-fumigation options include localized insecticide injection and heat treatment. The localized insecticide injection can be an effective control tool when the infestation is restricted to a small group of boards that are accessible. Heat treatment is a nonchemical method which is useful to treat the areas where the localized insecticide injection is not practical (e.g., entire attic). Even though these two control practices have unique advantages (e.g., lower environmental impact, no

need to evacuate house for several days, potential residual protection – for localized insecticide injection), their fundamental principles for applications have been largely unchanged over the last century. Furthermore, most of the research on these two non-fumigation methods has focused on the short-term mortality effect (e.g., immediate mortality within a few days of treatment). Therefore, our understanding on their long-term impacts on colony activity such as feeding / excavation, and termites' tolerance against environmental stressors (e.g., desiccation) is limited. Through our proposed research, we plan to further improve our understanding on these non-fumigation methods and their impact on termite colonies. By addressing these knowledge gaps in the localized insecticide injection and heat treatment for drywood termite control, our research effort may help to increase the understanding and adoption of these non-fumigation methods whenever appropriate.

D. Intended accomplishments, hypotheses, and research questions

The research described in this proposal specifically addresses the purpose and scope described in Solicitation Notice No. SPCB-25-01 ("Proposals should focus on new studies, treatments, or technology methods within the framework of integrated pest management (IPM) for the following structural pests: ants, cockroaches, **termites**, …").

In specific, our research will investigate: (1) impact of CSI or sub-target high temperature on feeding activity and microbial gut symbionts in western drywood termite, (2) impact of CSI or sub-target high temperature on desiccation tolerance in western drywood termite, and (3) combined impact of CSI and sub-target high temperature on feeding and long-term survival of western drywood termite colonies.

Ultimately, our effort may help to raise public awareness on extent of impact and utility of these non-fumigation methods in drywood termite management, possibly leading to increased adoption.

Research findings will be disseminated to pest management professionals via several outreach programs and extension outlets that the project members either organize or have access to.

Goals:

- Investigate if the ingestion of chitin synthesis inhibitors (CSIs) and exposure to the sub-target high temperature (45-47 °C) for 2 h have any impact on termites' feeding / excavating behavior.
- Investigate the impact of CSIs and the sub-target high temperatures on western drywood termite gut microbiome.
- Investigate the impact of CSIs and the sub-target high temperatures on western drywood termites' desiccation tolerance.
- Investigate the combined impact of CSI and high temperature on feeding activity and long-term survival in western drywood termite colonies.
- Disseminating the information and knowledge obtained from this research via educational extension events (e.g., UCR Urban Pest Management Conference, UCR Fumigation School, UC Berkeley Annual Termite Academy) and publication (e.g., UC IPM Green Bulletin, Pest Control Technology magazine).

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Xie, L., Slotsbo, S., Damgaard, C., and Holmstrup, M. 2024. Exposure to teflubenzuron reduces drought tolerance of collembolans. Chemosphere. Volume 361, 142448. https://doi.org/10.1016/j.chemosphere.2024.142448

Perry, D. T. and Choe, D.-H. 2020. Volatile essential oils can be used to improve the efficacy of heat treatments targeting the western drywood termite: evidence from a laboratory study. J. Econ. Entomol. 113: 1373-1381. https://doi.org/10.1093/jee/toaa177

Shamsuri, Q. S. and Ab Majid, A. H. 2024. 16S rRNA metabarcoding of gut microbiota between untreated and Chitin Synthesis Inhibitors bait treated in three subterranean termite species. Gene Reports, Volume 36, 101985. https://doi.org/10.1016/j.genrep.2024.101985.

ATTACHMENT 8. PROJECT DIRECTION

<u>OBJECTIVE 1.</u> INVESTIGATE THE IMPACT OF EXPOSURE TO THE SELECTED CSIS AND SUB-TARGET HIGH TEMPERATURE (45-47 °C) FOR 2 H ON TERMITES' FEEDING / EXCAVATING BEHAVIOR

<u>Experiment 1.1.</u> Investigate if the exposure to the selected CSIs for a limited amount time has any impact on termites' feeding behavior

- **Experimental design and procedure:** Three different CSIs will be used in this study: bistrifluron, chlorfluazuron, and noviflumuron. Besides these, other CSIs such as hexaflumuron and novaluron will be also considered. Stock acetone solutions of CSIs will be used to treat a piece of 4 by 2.7 cm balsa wood, providing 0.1 or 0.5% (wt/wt) of the CSI in the wood. Acetone only will be used for the control. One piece of the treated wood will be placed in a plastic Petri dish. A group of 10 - 20 pseudergates will be introduced per dish. The Petri dish will be kept in a humidity chamber kept at 26° C for a limited amount of time (e.g., 3 d). Once the heat treatment is completed, the treated termites will be moved to a different container (a 20-ml scintillation vial) with a piece of filter paper or wooden wafer with known weight. After a certain period of time, the amount of consumption of the paper will be measured to estimate the level of feeding by the termites. Mortality (number of dead termites) will be recorded daily. These values will be compared between the treatments and control using GLM or non-parametric methods, such as a Kruskall-Wallis test.
- **Deliverable:** Report detailing results along with tables, figures, images, and statistical analyses as needed to support the findings.
- **Target date for completion:** September 30, 2026

<u>Experiment 1.2.</u> Investigate if the exposure to the sub-target high temperature (45-47 °C) for a limited amount of time has any impact on termites' feeding behavior

- **Experimental design and procedure:** To simulate termite galleries in infested structural lumber, experimental arenas will be constructed from pieces of Douglas fir. The arenas (3.8 × 3.8 × 12.7 cm) will be designed to house a group of western drywood termites during small-scale heat treatments. Each arena will be consisted of two pieces of wood (1.9 cm height each). To hold the termites, a narrow channel (0.3 × 0.7 × 11 cm, with one open and one closed end) will be routed along the centerline of one piece from each pair. A sheet of clear acrylic (0.2 × 3.8 × 12.7 cm) will be placed over the top of the channel bearing bottom piece of the arena to facilitate observation. The top piece will be placed on the bottom piece, held together with two rubber bands and with the acrylic sheet pressed between them, to form a complete arena. In total, 10 - 20 pseudergates will be sued per each arena. An GC oven (5890A gas chromatograph; Hewlett-Packard, Palo Alto, CA) will be used to provide consistent heat treatment. Several chosen temperatures within the range of 45-47 $^{\circ}$C will be used for this study with a limited amount of treatment time (e.g., 2 h). Once the heat treatment is completed, the treated termites will be moved to a different container (a 20-ml scintillation vial) with a piece of filter paper with known weight. After a certain period of time (e.g., 14 d), the amount of consumption of the paper will be measured to estimate the level of feeding by the termites. Mortality (number of dead termites) will be recorded daily. These values will be compared between the treatments and control using GLM or non-parametric methods, such as a Kruskall-Wallis test.
- **Deliverable:** Report detailing results along with tables, figures, images, and statistical analyses as needed to support the findings.
- **Completion target date:** December 31, 2026

<u>OBJECTIVE 2:</u> INVESTIGATE THE IMPACT OF EXPOSURE TO THE SELECTED CSIS AND SUB-TARGET HIGH TEMPERATURE (45-47 °C) FOR 2 H ON WESTERN DRYWOOD TERMITE GUT MICROBIOME

<u>Experiment 2.1.</u> Investigate if the exposure to the selected CSIs for a limited amount time has any impact on western drywood termite gut microbiome

- **Experimental design and procedure:** The termites exposed to the selected CSIs from Experiment 1.1 will be used for this study. The timing of the investigation (e.g., how many days after the initial exposure to the CSIs) will be determined based on the findings from Experiment 1.1 (once the impact on feeding behavior becomes noticed). Hindgut samples will be collected and the microbiome community will be analyzed (diversity, abundance, etc.) by sequencing the microbial genes in the hindgut samples (16S Amplicon Sequencing). ZymoBIOMICS®-96 MagBead DNA Kit (Zymo Research, Irvine, CA) will be used for DNA extraction. The DNA samples will be prepared for targeted sequencing with the Quick-16S™ Plus NGS Library Prep Kit (Primer Set V3-V4). The final library will be sequenced on Illumina® NextSeq 2000™ with a p1 (cat 20075294) reagent kit (600 cycles). Unique amplicon sequences will be inferred from raw reads using the Dada2 pipeline (Callahan et al. 2016). A quantitative real-time PCR will be set up with a standard curve for absolute abundance quantification. Taxa composition plots will be used to illustrate the microbial composition at different taxonomy levels from phylum to species. The taxonomy abundance heatmap with sample clustering will be used to identify patterns of microbial distribution among samples. Alpha diversity and beta diversity values will be used to quantify microbial diversity of the samples. Preliminary investigation showed that this method is effective in detecting and characterizing the bacterial community of termite gut samples. Non-metric multidimensional scaling (nMDS) and permutational analysis of variance (PERMANOVA) will be used to quantify differences among samples and assess statistical significance (PRIMERe v 7.0.13) (Arango et al. 2021).
- **Deliverable:** Report detailing results along with tables, figures, images, and statistical analyses as needed to support the findings.
- **Due Date:** March 31, 2027

Experiment 2.2. Investigate the impact of high temperatures (45-47 °C) on western drywood termite gut microbiome

- **Experimental design and procedure:** The termites exposed to sub-target high temperature (45-47 °C) for a limited amount of time (Experiment 1.2) will be used for this study. The timing of the investigation (e.g., how many days after the heat treatment) will be determined based on the findings from Experiment 1.2 (once the impact on feeding / excavating behavior becomes noticed). The methods for collection of hindgut samples and microbiome community analyses will be identical to those for Experiment 2.1.
- **Deliverable:** Report detailing results along with tables, figures, images, and statistical analyses as needed to support the findings.
- **Due Date:** June 30, 2027

OBJECTIVE 3: INVESTIGATE THE EFFECT OF PRESENCE OF UNTREATED NESTMATES ON THE RECOVERY OF GUT MICROBIOTA AFTER EXPOSURE TO THE SELECTED CSIS AND SUB-TARGET HIGH TEMPERATURE

Experiment 3.1. Investigate the effect of presence of nestmates on recovery from the CSI treatment (sharing their gut microbiome through trophallaxis)

- **Experimental design and procedure:** The termites exposed to CSI-treated wood for a limited amount of time (Experiment 1.1) will be used for this study. A group of treated termites will be grouped together with the untreated termites for 2 days. The ratio between donors (untreated termites) and recipients (treated termites) will be 1:1. Preliminary observations will be used to determine if the 2-day period is long enough to allow substantial level of trophallaxis to occur between nestmates. The recipients (treated termites) will be subsequently moved to a separate container, and their survivorship and feeding activity will be tracked over time. The overall

experimental protocol will be identical with what is described for Experiment 1.1. If needed, hindgut samples will be collected and the microbiome community will be analyzed (diversity, abundance, etc.) by sequencing the microbial genes in the hindgut samples (16S Amplicon Sequencing).

- **Deliverable:** Report detailing results along with tables, figures, images, and statistical analyses as needed to support the findings.
- **Due Date:** December 31, 2027

<u>Experiment 3.2.</u> Investigate the effect of presence of nestmates on recovery from the heat treatment (sharing their gut microbiome through trophallaxis)

- **Experimental design and procedure:** The termites exposed to sub-target high temperature (45-47 °C) for a limited amount of time (Experiment 1.2) will be used for this study. A group of heat-treatment termites will be grouped together with the untreated termites for 2 days. The ratio between donors (untreated termites) and recipients (treated termites) will be 1:1. Preliminary observations will be used to determine if the 2-day period is long enough to allow substantial level of trophallaxis to occur between nestmates. The recipients (treated termites) will be subsequently moved to a separate container, and their survivorship and feeding activity will be tracked over time. The overall experimental protocol will be identical with what is described for Experiment 1.2. If needed, hindgut samples will be collected and the microbiome community will be analyzed (diversity, abundance, etc.) by sequencing the microbial genes in the hindgut samples (16S Amplicon Sequencing).
- **Deliverable:** Report detailing results along with tables, figures, images, and statistical analyses as needed to support the findings.
- **Due Date:** December 31, 2027

<u>OBJECTIVE 4:</u> INVESTIGATE THE IMPACT OF EXPOSURE TO THE SELECTED CSIS AND SUB-TARGET HIGH TEMPERATURE (45-47 °C) FOR 2 H ON WESTERN DRYWOOD TERMITES' DESICCATION TOLERANCE.

<u>Experiment 4.1.</u> Investigate if the exposure to the selected CSIs for a limited amount time has any impact on western drywood termites' desiccation tolerance

- **Experimental design and procedure:** The termites exposed to CSI-treated wood for a limited amount of time (Experiment 1.1) will be used for this study. Cuticular permeability will be calculated and compared between the heat-exposed and unexposed termites. Separate groups of live and dead termites will be used to evaluate if there was a difference between physical water loss and physiologically mediated water loss from their bodies. Termites prepared for the dead groups will be killed with ethyl acetate fumes and immediately used for experimentation. The rate of weight loss (as water vapor) over 12 h will be calculated for 10 groups each of 10 live and 10 dead workers/pseudergate. Cuticular permeability (CP) [the amount of water lost (µg) per unit surface area (cm^2) per unit time (h) per unit saturation deficit (mmHg)], which is often used to describe and compare evaporative water loss from body surface of insects and other arthropods, will be calculated via a method similar to Sponsler and Appel (1990) by using the 12-h water loss data. Surface area will be estimated based on the weight (Haggsma et al. 1996), and the saturation deficit will be calculated as in Sponsler and Appel (1990). CP values will be compared between different treatments using GLM or a non-parametric Kruskal-Wallis test.
- **Deliverable:** Report detailing results along with tables, figures, images, and statistical analyses as needed to support the findings.
- **Due Date:** March 31, 2028

<u>Experiment 4.2.</u> Investigate if the exposure to high temperatures (45-47 °C) for a limited amount time has any impact on western drywood termites' desiccation tolerance

- **Experimental design and procedure:** The termites exposed to sub-target high temperature (45-47 °C) for a limited amount of time (Experiment 1.2) will be used for this study. The timing of the investigation (e.g., how many days after the heat treatment) will be determined based on the findings from Experiment 1.2 (once the impact on feeding / excavating behavior becomes noticed). The methods for cuticular permeability analyses will be identical to those for Experiment 4.1.
- **Deliverable:** Report detailing results along with tables, figures, images, and statistical analyses as needed to support the findings.
- **Due Date:** March 31, 2028

<u>OBJECTIVE 5:</u> INVESTIGATE THE COMBINED IMPACT OF THE SELECTED CSI AND SUB-TARGET HIGH TEMPERATURE ON WESTERN DRYWOOD TERMITES' FEEDING AND LONG-TERM SURVIVAL

<u>Experiment 5.1.</u> Investigate if the exposure to selected CSI and sub-target high temperature for a limited amount of time has any impact on feeding behavior and long-term colony survival of western drywood termite

- **Experimental design and procedure:** For this experiment, one CSI and one temperature condition will be used based on the finding in the earlier objectives (e.g., lowest temperature with significant impacts). Exposure to CSI and heat will be done using the experimental arenas constructed from pieces of Douglas fir and a GC oven (see Experiment 1.2). Once the heat treatment is completed, the treated termites will be moved to a different container (a 20-ml scintillation vial) with a piece of filter paper with known weight. After a certain period of time (e.g., 14 d), the amount of consumption of the paper will be measured to estimate the level of feeding by the termites. If the

wooden arena is used for the experiments, the number of fecal pellets produced per day will be used as a proxy of feeding activity. Mortality (number of dead termites) will be also recorded daily. These values will be compared between the treatments and control using GLM, survival analysis, or non-parametric methods, such as a Kruskall-Wallis test. Controls (CSI only and heat exposure only) and treatment (combination) will be replicated 10 times.

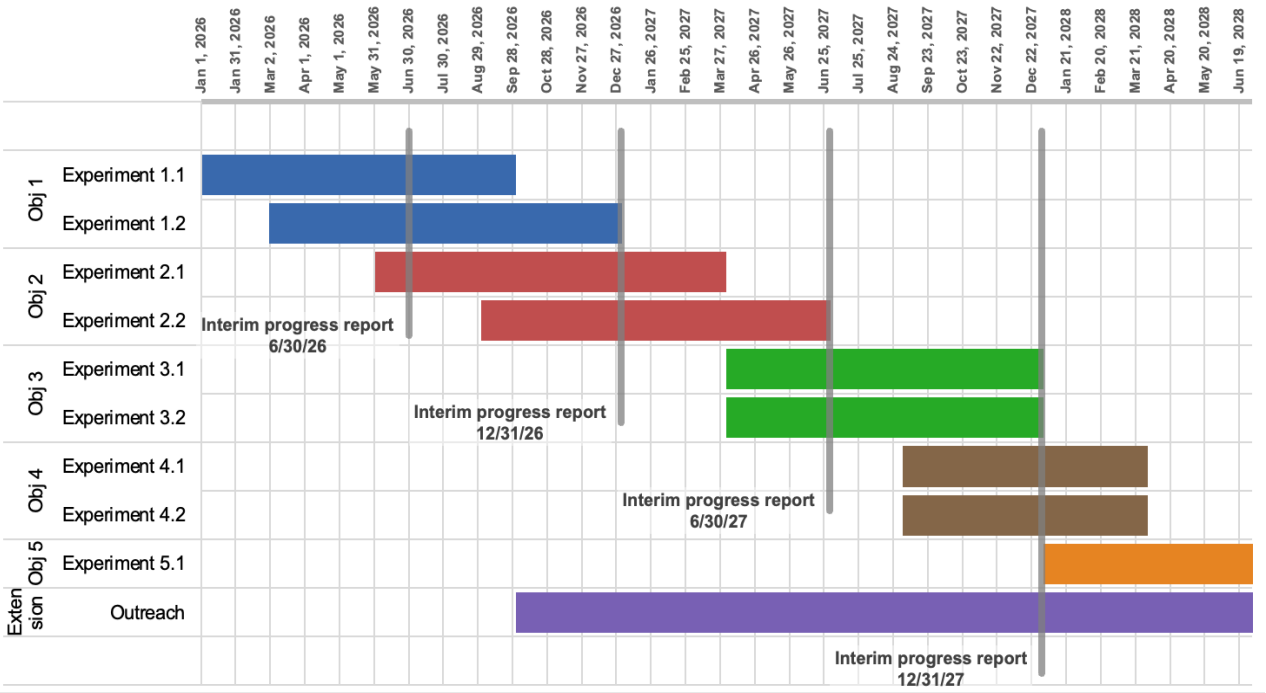
- **Deliverable:** Report detailing results along with tables, figures, images, and statistical analyses as needed to support the findings.
- **Due Date:** June 30, 2028

TIME ALLOCATION AND MONITORING SYSTEM

The principal investigator (Choe) will devote 5% of his time to this project. A postdoctoral scholar (TBD) will devote 100% of time for the proposed research. The qualifications, designated tasks, and management of the research team are described below, in Attachment 9. Choe will monitor and oversee all aspects of the proposed research, and the postdoctoral scholar will carry out the detailed activities of the proposed research. The postdoctoral scholar will meet weekly with Choe to discuss progress on the research, and goals for the near term and long term. Choe and the postdoctoral scholar will present the research about once per 6 weeks at the weekly Choe laboratory meeting. This will allow for additional input and advice from scientists and entomologists who are not directly involved in the proposed research. Also, starting towards the end of the first year of the project (October 2026), the project team will also start disseminating some of the research findings vias various routes of cooperative extension and outreach. For example, the project findings and new discoveries will be presented at extension events such as UC Berkely Termite Academy (early March), UCR Urban Pest Management Conference (late March) and UCR Fumigation School (mid-October). PI (Choe), co-PI (Lee), and one of the key

personnel (Rust) are directly involved in organizing these events. Towards the end of the project (mid-2028), the project findings and data will be also disseminated via a couple of extension publications such as UC IPM's Green Bulletin or Pest Control Technology magazine. These planned extension events and publications will serve as additional mechanisms to keep the project moving forward and monitor the progress.

TIMELINE OF THE PROPOSED RESEARCH



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ATTACHMENT 9. NARRATIVE OF QUALIFICATIONS

PI of the project, Dong-Hwan Choe, and other key participants have prior scientific research experiences that are relevant to the research described in the current proposal. All of their previous projects (funded or not) were completed within the allotted time frame without any exception so far. Here are summaries for those projects.

- **Improving the efficacy of heat treatment targeting the western drywood termite with a volatile essential oil component.** Based on the laboratory as well as semi-field experiments, we demonstrated the challenge the heat sinks provide for the drywood termite heat treatment. The volatile essential injected in the heat sink area effectively addressed this heat sink issue, providing a significant potential to improve the control efficacy of the heat treatment. This funded research resulted in two published journal articles.
    - Perry, D. T. and D.-H. Choe. 2020. Volatile essential oils can be used to improve the efficacy of heat treatments targeting the western drywood **termite**: evidence from simulated whole house heat treatment trials. J. Econ. Entomol. 113: 2448–2457.
    - Perry, D. T. and D.-H. Choe. 2020. Volatile essential oils can be used to improve the efficacy of heat treatments targeting the western drywood **termite**: evidence from a laboratory study. J. Econ. Entomol. 113: 1373-1381.
- **Toxicity and transfer of chitin synthesis inhibitors in western drywood termite.** In this project, three chitin synthesis inhibitors were tested against the western drywood termites in a choice or a no-choice setting. Basic toxicological investigation (survival analysis, final mortality) as well as transfer experiment to examine the potential of the chitin synthesis inhibitors for the drywood termite management. The outcome of the project was encouraging, leading a way for further investigation and development of the approach. This funded research resulted in the following

journal article.

- Poulos, N. A, C.-Y. Lee, M. K. Rust, and D.-H. Choe. 2025. Toxicity and horizontal transfer of chitin synthesis inhibitors in the western drywood **termite** (Blattodea: Kalotermitidae). J. Econ. Entomol. 118: 1373-1381.

- **Fecal / gut microbiome of western drywood termite.** In this recent project, we analyzed the fecal microbial community of western drywood termites. By examining temporal changes in microbial genes (abundance and diversity), we were hoping to detect any microbial signature which can be used to develop a novel method of detecting live or active infestations of the western drywood termites based on the fecal samples. This manuscript has been submitted for a journal publication, and is currently in revision.
    - Poulos, N. A., L. Ngor, C.-Y. Lee, Q. McFrederick, and D.-H. Choe. Bacterial communities of fresh and aged fecal pellets in western drywood termite (Blattodea: Kalotermitidae) and their potential use as biomarkers of recent or active infestations. J. Econ. Entomol. (in revision)

Some of the observations from above projects (i.e., apparent reduction of fecal pellet production by the treated but live termites) led to some of the key questions that will be addressed in the current projects.

- **Dissemination of the research findings and new knowledge via various extension events and publication(s).** For last 13 years, PI (Choe) has been organizing annual UC Riverside Urban Pest Management Conference, which is the important extension and outreach events for urban pest management professionals with DPR (Department of Pesticide Regulation) and SPCB (Structural Pest Control Board) licenses (https://urbanpest.ucr.edu/conference) in Sothern California. The information from this research will be share with our conference attendees (about 200 professionals yearly). Research findings will be also reported via academic journals and trade

magazines, and other online media. For the Northern California, Dr. Andrew Sutherland (Urban IPM Advisor, collaborator) will be assisting in disseminating the new knowledge learned from the proposed project via different extension events and other means. Sutherland has been involved in organizing annual UC Berkeley Termite Academy for several years, and that would be another potential event where the knowledge from the current project can be disseminated to the pest management industry.

GreenTech HEAT SOLUTIONS

July 8, 2025

Dong-Hwan Choe, CE Specialist/Professor
Department of Entomology
University of California, Riverside

To Whom It May Concern,

Please allow me to introduce myself. My name is Michael R. Linford, Ph.D. I developed, commercialized, patented and then published the methodology for the use of convected heat for the eradication drywood termites, powder post beetles and microbial infestations whether fungal, bacterial or viral. I have previously worked with UC Riverside to enhance the practical use of high temperatures for drywood termite treatments. The research done by their Department of Entomology has been very important and extraordinarily valuable to enhance efficacy and reduction of harmful gasses in drywood termite treatments in California.

I am strongly supportive of the research project proposed by Dr. Dong-Hwan Choe and his colleagues. The project title is "Impact of high temperature and chitin synthesis inhibitors in gut microbial symbiont community and desiccation tolerance in western drywood termite."

The proposed research project is not only scientifically interesting, but also highly relevant to practical drywood termite management in California. The outcome of the project will be useful in improving the quality, efficacy, and sustainability of drywood termite control in our country, particularly in California.

Obtaining more knowledge on how chitin synthesis inhibitors and heat treatments really work in drywood termite populations can be an important step to reduce our reliance on traditional fumigation with sulfuryl fluoride. Their potential impact on microbial symbionts of termites and termites' desiccation tolerance is fascinating, and knowledge on this topic will be helpful to thoroughly understand the impact of these non-fumigation treatment options. Information from this research will be also useful to inform the customers of end-users of pest management industry.

It aligns with our pest control industry's mission of providing cost-effective, safe, and eco-friendly solutions for homeowners and tenants, with the minimal environmental impact possible.

Thank you for your consideration of the important project.

Best regards,

Michael R. Linford, Ph.D. and CEO
GreenTech Heat Solutions

07/07/2025

To:
California Structural Pest Control Board (CA-SPCB)
Research Grant
Sacramento, CA

Ref: **"Impact of high temperature on gut microbial symbiont community, desiccation tolerance of western drywood termites."**

Dear Pest Management Research Committee,

As an industry leader in pest control, I am excited to support Dr. Dong Hwan Choe's cutting-edge research proposal. The study, which explores the impact of high temperatures on the gut microbial symbiont community and desiccation tolerance of Western Drywood Termites, alongside the use of CSI (chitin synthesis inhibitors) to control drywood termite populations, is both timely and critical for advancing termite control solutions in California.

At Rentokil-Terminix, we constantly seek innovative methods to improve the efficacy and environmental sustainability of our pest management strategies. Dr. Choe's proposal perfectly aligns with these goals. His work on heat treatments has already shown tremendous potential as an alternative to fumigation, and the addition of CSI could lead to even more groundbreaking approaches to termite control.

What makes this project particularly exciting is its potential to provide eco-friendly solutions in an era of climate change. According to our calculations, the carbon emissions generated from the propane heat treatment can be 12 to 200 times lower than what would be produced by sulfuryl fluoride fumigation for a similar structure, depending on the structure characteristics. In an era where reducing carbon footprints is crucial, this research could provide the missing support for a significant leap forward in a more sustainable Drywood termite control. The combination of heat treatment with CSI technology offers a novel, dual-pronged strategy to control termite populations, addressing both immediate and long-term concerns while significantly minimizing environmental impact.

There could be no better time for the Structural Pest Control Board to support such research than today. The Pest Control Industry and the world itself are at a pivotal moment, with increasing demand for green and effective alternatives. This research could lay the groundwork for widespread change in the way termite control is handled, not only in California but nationwide. The knowledge and strategies developed through this study would benefit both the pest control industry, California homeowners, and the environment for years to come.

I urge you to consider Dr. Choe's research proposal and give it the support it deserves. The insights gained from this study will undoubtedly have a lasting, positive impact on pest management practices while contributing to broader environmental goals.

Thank you for your time and consideration.

Sincerely,

Claudio Salem - DVM - BCE
Regulatory & Compliance Manager
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claudio.salem@rentokil.com

IPM4YOU

PEST & TERMITE

July 9, 2025

Structural Pest Control Board Pest Management Research Grant

RE: Dong-Hwan Choe's proposal entitled "Impact of High Temperature and Chitin Synthesis Inhibitors on Gut Microbial Symbiont Community and Desiccation Tolerance in Western Drywood Termite"

IPM4YOU Pest & Termite, Inc. is a Branch 2 and 3 Pest Management company, specializing in Integrated Pest Management. In 2021, we rebranded (from EXCIMEX) and expanded our professional services.

IPM4YOU Pest & Termite, Inc. has enjoyed a professional relationship with Dr. Choe and his UCR entomology colleagues since 2011. Dr. Choe continues as a valued professional colleague, and a key element in our business plan. The idea of forming a PMP (Pest Management Professional) was part of our MBA program at UCSD Rady School. Our backgrounds are varied, and include science, academics and military. With little practical or professional experience in PMP, Dr. Choe willingly provided valuable assistance, and solid recommendations for us to go forward. Our company has grown, and prospered, in no small measure to Dr. Choe, his time and professional talent.

We have actively participated as collaborators in the "Healthy Families and Communities-Bed Bug Integrated Pest Management" study with Dr. Choe. We have also provided field work opportunities, including actual field work experience for graduate students pursuing a professional career in urban pest management. His leadership, "hands on" assist, encouragement and direct involvement resulted in a structured plan for the orderly inspection, isolation and control of infestation in an aging affordable housing facility in the East Village of San Diego. As a direct result of his efforts as the team leader, the original population of residents was successfully relocated, and a comprehensive IPM plan implemented in a new 200+ unit site.

With the increasing volatility of the California real estate market, and exponential growth in residential needs in drywood termite management, Dr. Choe's research will provide important technical information for the more challenging situations. The project proposed by Dr. Choe for the SPCB's Pest Management Research Grant would benefit the pest management industry as

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well as the public. The research will provide interesting and useful information to understand the true impact of high temperature and insect growth regulators to drywood termite colonies. The mortality of insect colony is important, but the non-lethal behavioral impact will be also important to understand the true impact of a treatment option. The feeding and tunneling activity of drywood termite in the structural wood is the reason for their pest status. Because drywood termites are confined in a piece of wood which is relatively dry, any impact on their tolerance against desiccation would be useful for their control. Since they are a common pest in urban and suburban areas in California, there will be virtually unlimited opportunity for him and his staff to research and gather specimens. We look forward to continuing our professional involvement by assisting in locating a source of termites, infested wood, etc. I have no doubt that many PMPs from California (including we IPM4YOU) would be interested in hearing and learning the research findings from this project.

Dr. Choe has our full support for this project.

James Panknin

James Panknin
President and General Manager
OPR 13777