**Evaluation of bait station system efficacy**

**for reduced-risk subterranean termite management in CA**

**Final Report**

**Project Period:** October 10, 2018 – August 31, 2022

**Principle Investigator:** Dr. Andrew Sutherland [University of California Cooperative Extension (UCCE), University of California Statewide Integrated Pest Management Program (UC IPM)]

**Collaborators:** Dr. Siavash Taravati (UCCE, UC IPM), UCCE staff members, collaborating pest control operators (PCOs), collaborating property owners, collaborating laboratories, collaborating termite bait system manufacturers.

**Executive Summary**

This project aimed to evaluate the efficacy of three California-registered termite bait systems against subterranean termites, in collaboration with PCOs and property owners, at 15 single-family homes in the San Francisco Bay Area and the Los Angeles Basin (Objective 1). Though all 15 homes had documented subterranean termite activity immediately adjacent to the structures and, in most cases, documented incidence of one or more identified termite colonies, none became infested during the two-year evaluation period. Furthermore, none of the identified termite colonies collected from bait stations during the project were ever observed again, suggesting that they were eliminated. This project also aimed to increase our knowledge about seasonal and spatial effects on subterranean termite incidence within bait stations in California (Objective 2). At our research station in the San Francisco Bay Area, we observed that bait stations installed during the winter were initially intercepted by foraging termites, on average, 100 days sooner than stations installed during the summer. Spatial factors did not significantly influence bait interception time within our experimental design. There were no significant differences in bait systems / products with regards to bait interception time. We believe these findings will help to increase adoption of bait station services in California and will help PCOs to reduce bait interception times by targeting specific seasons for initial system installations.

Significant tasks, findings, outcomes, and observations associated with this project are reported below. In some cases, hyperlinks have been provided for access to more in-depth information.

**Background**

Subterranean termites (Blattodea: Rhinotermitidae) are the most important wood-destroying organisms in California. The western subterranean termite, *Reticulitermes hesperus* (a species complex), is a native insect found within many different natural and urban ecosystems throughout the state. Management is often necessary to prevent irreparable damage to homes, businesses, and other wooden structures. The prevailing control strategy used in California involves drenching or injection of liquid insecticide into soil and other substrates surrounding structures, either as whole perimeter applications or as targeted local treatments. In many other parts of the world, termite baits are considered more effective than liquid treatments and are considered as the standard or prevailing control measure. One reason baits may be more effective than liquids is that they can eliminate entire colonies of termites, whereas liquid treatments may only partially eliminate large termite colonies and may only serve as temporary barriers to termite attack of the structure. This is especially true when considering the Formosan subterranean termite, *Coptotermes formosanus*, an invasive species now found in southern California that is known to form colonies of millions of termites foraging over very wide ranges. Another potential advantage of using baits for termite control is that the active ingredients, insect growth regulators (IGRs), are not known to negatively affect nontarget organisms or the environment. In contrast, most of the active ingredients used within liquid termiticides; fipronil, imidacloprid, pyrethroid insecticides; are known to contaminate California's surface water ecosystems and have seen some application types recently regulated or restricted by the State. The pest control industry has been slow to adopt baits in California, as compared to most other parts of the world where subterranean termites are serious pests. Potential reasons for this include licensing barriers (a Field Representative license is required when using bait stations as monitors), consumer protection regulations (baits may not be used to financially "clear" infested structures, as per the Structural Pest Control Act), time required for control, and perceptions of poor control. This project was designed to demonstrate that bait services can be effective in California and, considering newer product labeling, can often be provided by Applicators.

**Objective 1. Conduct collaborative field research at participating single-family homes to evaluate bait system efficacy:**

Several PCO companies were identified that expressed interest in evaluating bait systems as potential service offerings within their operations. Some of these companies had experience with baits, while some gained their first experiences with bait systems through this project. Companies received research stipends to subsidize their participation ($1000 / home / year). In some cases, these funds were used to incentivize property owner participation via free or reduced-cost services. The UC research team (Sutherland, Taravati, and staff) and participating PCOs performed dozens of structural inspections to locate prospective homes for the study. Fifteen single-family homes were eventually selected, based on several experimental criteria:

- Documented activity of subterranean termites within one meter of the foundation of the residential structure. In some cases, swarms were observed. In other cases, live termites were collected from stumps, landscape edging, monitoring devices, or wood debris.
- No recent (within five years) history of liquid termiticide application.
- No significant structural infestations detected during initial inspection.

**List of study home locations, participating PCOs, and participating bait manufacturers:**

1. Hayward, Alameda County. Participating pest control operator: Omega Termite and Pest Control. Bait station system evaluated: Advance Termite Bait System / Trelona (BASF). Study period: March 2019 – March 2021
2. Oakland, Alameda County. Omega Termite and Pest Control. ATBS / Trelona. Study period: August 2020 – August 2022.
3. Berkeley, Alameda County. Participating PCO: Western Exterminator. Bait system evaluated: Sentricon Always Active / Recruit HD (Corteva). Study period: March 2020 – March 2022.
4. San Jose, Santa Clara County. Participating PCO: Thrasher Termite & Pest Control. Bait system evaluated: Exterra / Isopthor (Ensystex). Study period: February 2020 – February 2022.
5. San Jose, Santa Clara County. Thrasher Termite & Pest Control. Exterra / Isopthor (Ensystex). Study period: February 2020 – February 2022.
6. San Leandro, Alameda County. Western Exterminator. Sentricon Always Active / Recruit HD. Study period: January 2020 – January 2022.
7. Martinez, Contra Costa County. Western Exterminator. Sentricon Always Active / Recruit HD. Study period: January 2020 – January 2022.
8. Alameda, Alameda County. Omega Termite and Pest Control. ATBS / Trelona. Study period: January 2020 – January 2022.
9. San Jose, Santa Clara County. Thrasher Termite & Pest Control. Exterra / Isopthor (Ensystex). Study period: February 2020 – February 2022.
10. Huntington Beach, Orange County. Western Exterminator. Sentricon Always Active / Recruit HD. Study period: August 2019 – August 2021.
11. Monrovia, Los Angeles County. Participating PCO: Excellence Pest Control. Bait system evaluated: ATBS / Trelona. Study period: August 2019 – August 2021.
12. Pasadena, Los Angeles County. Excellence Pest Control. ATBS / Trelona. September 2019 – September 2021.
13. Pasadena, Los Angeles County. Participating PCO: Homeshield Pest Control. Bait system evaluated: Exterra / Isopthor. Study period: November 2019 – November 2021.
14. Pasadena, Los Angeles County. Participating PCO: Homeshield Pest Control. Bait system evaluated: Exterra / Isopthor. Study period: November 2019 – November 2021.
15. Glendale, Los Angeles County. Western Exterminator. Sentricon Always Active / Recruit HD. Study period: February 2020 – February 2022.

Bait stations, baits, service equipment, and, in some cases, training, were provided by manufacturers to participating PCOs. The UC research team and the PCOs installed bait systems according to product labels, usually with one bait station for every 10 - 20 linear feet of the structural perimeter. Since all 15 sites had confirmed termite activity at the perimeter, all bait stations were installed with active ingredients present from Day 1. The UC research team installed monitoring stations (Ensystex EZE with wooden blocks, see Figure 1) immediately

adjacent to each baits station. The UC team then visited each participating home every three months for two years, checking termite activity within monitoring stations and collecting termites for DNA analysis whenever possible. The PCOs and the UC team visited each participating home every six months to check termite activity within bait stations, replenish baits (as per product label), and to collect termites for DNA analysis. Collected termite specimens were sent to a collaborating lab for DNA analysis. Each collected sample was then assigned a "Colony ID" based on its genetic signature, distinguishing it from all other colonies.

Through this project, our team completed 120 quarterly inspections of monitoring stations and 60 bi-annual inspections of bait stations. Foraging termites were observed and collected during initial inspections, from wood blocks during quarterly inspections, and from bait matrices during bi-annual inspections with PCOs. In some cases, termites were observed and collected from bait stations only six months after installation (Figure 1).

As part of this work, 132 separate samples of *Reticulitermes* foragers were collected, curated, and sent to a collaborating laboratory (see Figure 2). DNA analysis revealed that many research sites included several (3 – 5) unique colonies; one site included 15 unique colonies.

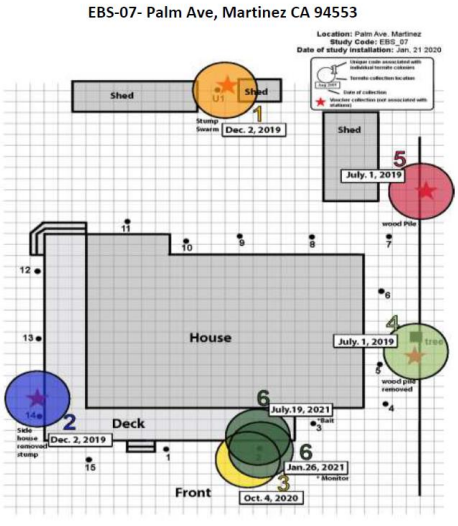
List of unique termite collections and colony identities by site:
https://docs.google.com/spreadsheets/d/16P6PRhrN-rrNE0WJEXb5M3XPi-b_5Qty/edit?usp=sharing&ouid=114980821805913012004&rtpof=true&sd=true

Figure 1. Sentricon Always Active bait tube damaged by termites (left) and associated bait station containing termites (right) approximately six months after installation at Berkeley site.


Figure 2. Vials containing *Reticulitermes hesperus* termites collected from research sites, preserved in 100% ethanol, and curated for later DNA analysis to determine colony identity.

Preliminary data analyses suggest that all three bait systems have been effective at eliminating western subterranean termites at our study sites in California. Bait was consumed at all 15 sites, to varying degrees. No termite colony recovered from bait stations has ever been detected again, according to colony identity as per DNA analysis.

To aid in data visualization, we created maps for each site, indicating exactly when and where termites were observed, collected, and assigned a colony identification number (according to DNA analysis). **Below, we share the map for our Martinez site.** All other maps, with accompanying site-specific final reports, can be accessed within the following online folder: https://drive.google.com/drive/folders/19pXkHyWOnWgqtx7Pke0TUMPuNi3fUP3A?usp=sharing




| Colony ID | Date of Collection | Location |
|---|---|---|
| 1 | Dec 2, 2019 | Stump in back of property between sheds |
| 2 | Dec 2, 2019 | Left side of house, old stump next to deck |
| 3 | Oct 4, 2020 | Monitoring station #2 |
| 4 | July 1, 2019 | Wood pile by poplar tree |
| 5 | July 1, 2019 | Wood pile by right side fence |
| 6 | Jan 26, 2021<br>July 19, 2021 | First collected from Monitoring station #2, then from Bait station #2. |

A complete table of raw data can be accessed and viewed here: https://docs.google.com/spreadsheets/d/1m5f5iufXX0sNqrDcfVOlnzpV52W-Lode/edit?usp=sharing&ouid=114980821805913012004&rtpof=true&sd=true

Southern California sites experienced much lower subterranean termite activity during the two-year evaluation period than did northern California sites. No more than one unique termite colony was collected at each of the southern California sites and, in a few cases, no viable collections of foraging termites could be made during the study period. The efficacy trend at these sites was the same, however, with no structural infestation detected during the study.

We have initiated surveys for participating pest control operators and property owners to learn about attitudes and intentions associated with subterranean termite bait services. For PCOs, we are most interested in whether they increased knowledge as part of this project, whether they will continue to provide bait services in the future, and the reasons behind these decisions. For property owners, we are most interested in measuring their satisfaction with the services provided and whether they will continue to hire PCOs for bait services in the future. These surveys can be found at the following links:

https://docs.google.com/forms/d/e/1FAIpQLSfTGhVKGTP4k3AUUjMrY_yrPwxBNjkSyjngIWVXJ0REWwlGqg/viewform

https://docs.google.com/forms/d/e/1FAIpQLSfMfEnvXvdUw3zSC26hiiKhuretc53xqDSwaAUdYCKKSDOpsA/viewform

We have plans to publish one peer-reviewed journal article, one trade magazine article, and one UC IPM newsletter article reporting on findings from this field research. Outreach has already begun, at UC Riverside's Urban Pest Management Conferences, PCOC's *Termite Academy*, the Entomological Society of America, and at local PCOC District meetings.

**Objective 2. Conduct observational and manipulative research at UC field station(s) to describe colony attributes, seasonal phenology in CA, and determine time-to-attack for registered bait systems:**

Note: some of the text and figures below was taken from our original trade magazine article 'Subterranean termite baiting: system options and seasonal considerations', published within *Pest Control Technology* in April 2022 and freely available at this link: https://www.pctonline.com/article/subterranean-termite-baiting-system-options-and-seasonal-considerations/

One explanation for bait interception time (aka "time-to-attack") problems in California may be explained the state's unique Mediterranean climate (hot summers with little to no rain, cool winters that typically produce the entire annual precipitation amount) and prevailing soil textures (high proportions of clay). Termite foraging at or near the soil surface may be limited or even nonexistent during summer months, especially when areas are not irrigated. Some research supports this idea: *Reticulitermes hesperus*, the western subterranean termite, has been observed to forage near the surface mostly during winter months in its native habitat in southern

California. This suggests that bait stations installed in summer may sit uninvestigated for six months or more. To test this hypothesis, and to observe whether time-to-attack could be reduced by targeting specific seasons for installation, we established five research plots during 2019 at the UC Berkeley Richmond Field Station directly on top of known termite colonies. Naturally occurring subterranean termites (*Reticulitermes* spp.) had been observed, as foraging workers or brood chamber aggregations, and collected at the center of each plot.

Around these five areas of "documented termite activity", we established three concentric rings of bait stations at three distances from the center, installing one station from each of three registered systems along each of the rings at the beginning of each season over one year, for a total of 36 bait stations per plot (Figure 3). We didn't want to kill the termites in these plots because that would significantly confound our data, so we used cellulose bait matrices from manufacturers that did not contain the IGR active ingredients. We also installed a monitoring device (Isopthor EZE station housing containing wooden monitoring blocks) at the center of each plot and along each of the three distance rings. By the end of the year, we had installed 200 stations for this investigation. We then checked each station every two months (about every 60 days) after its installation for two years, opening and inspecting up to 100 stations per month.

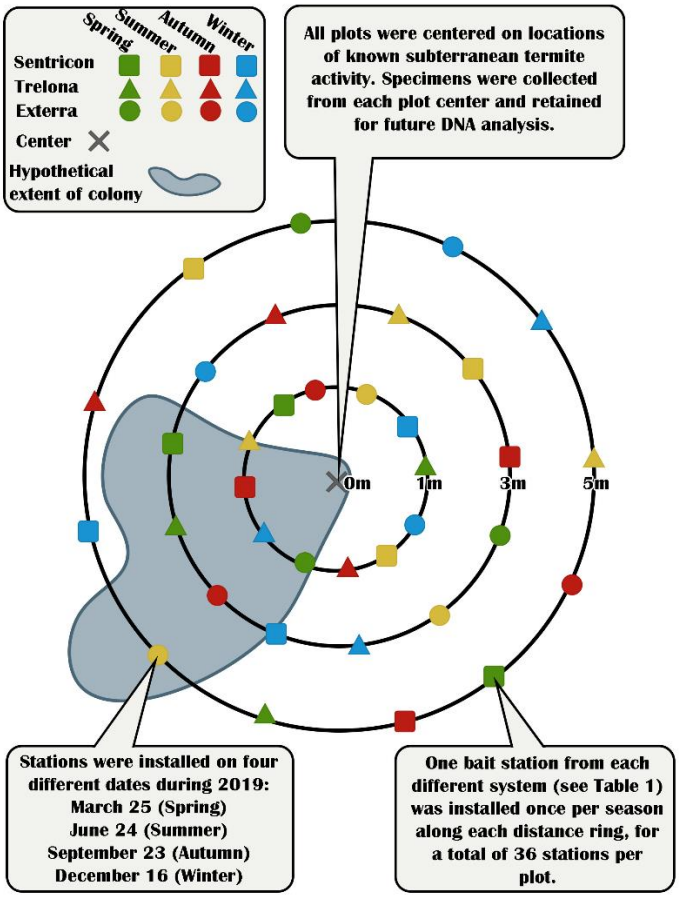



Figure 3. Schematic diagram of experimental design used to evaluate the effects of installation season, distance from observed activity, and bait system on bait interception time.

Of the 180 bait stations and 20 monitoring stations installed, 78 bait stations and 9 monitoring stations had been hit by the end of the two-year project period, representing an overall hit rate of 44%. Three stations were attacked within 60 days after installation, and ten stations were attacked within 120 days. Overall, the average bait interception time was 367 days. This result supports the general claims of California's pest control operators that baiting may take too long for most remedial termite control jobs. There were no significant differences between the three bait systems, with average time-to-attack for all three between 327 and 383 days. We did not detect any significant differences in time-to-attack among the three distance rings. Proximity to adjacent stations and type of adjacent stations were considered as potential factors influencing time-to-attack, but there were no measurable effects detected.

Our study's main question was whether installation season significantly impacts "time-to-attack" due to seasonal differences in termite foraging in California. To answer this, we pooled data from all five sites and all three bait systems and then considered just the first year of observations. The result was clear: time-to-attack for stations installed at the beginning of winter (December 16) was more than 100 days less than for stations installed at the beginning of summer (June 24) (194 days vs. 296 days). This result was statistically significant. Installations at the beginning of spring and beginning of autumn were intermediate (282 and 268, respectively) and statistically inseparable from the other two seasons (Figure 4).

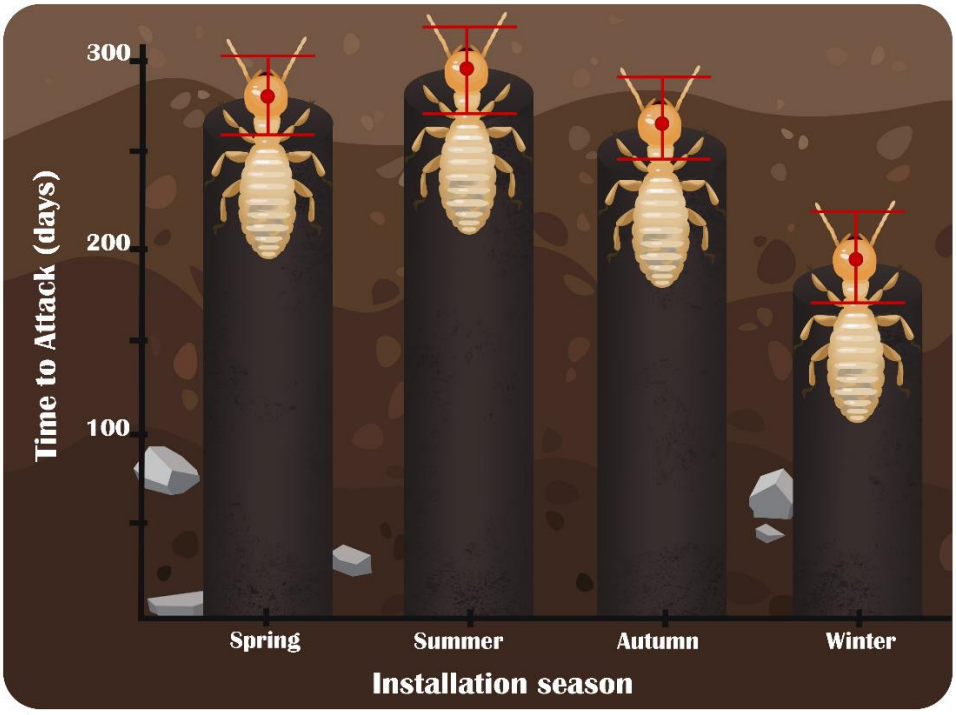



Figure 4. Time required for western subterranean termites to begin consuming baits installed during four different seasons in California's San Francisco Bay Area. Red points on termite heads represent the average time-to-attack (number of days between installation and first observation of bait consumption). Red bars extending above and below each point represent standard error of the mean.

In addition to the trade magazine article referenced and linked above, our team published a peer-reviewed scholarly journal article reporting on these findings. It is freely available within the open access online journal *Insects:*

https://www.mdpi.com/2075-4450/13/5/445/htm

**Overall conclusions**

Bait stations systems may be very useful pest control tactics for use against subterranean termites in California, especially when dealing with Formosan subterranean termites, very large colonies of native western subterranean termites, multiple colonies, sensitive sites, or sites where liquid treatments have failed. According to the labels of the three products evaluated, systems can be installed with active ingredients present on Day 1, provided a licensed Field Representative has detected and identified the target species at the site. Licensed Applicators may, according to label language and California's Structural Pest Control Act, then service bait stations, replenishing bait that has been consumed or damaged. Two of the systems evaluated allow for annual inspections, while one allows for bi-annual (every six months) inspections. Operators in California may decrease the bait interception time, and therefore the perceived early efficacy, by targeting initial installations for the beginning of the wet season.