Cooking Termites in the Aloha State

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The state of thermal pest eradication in Hawaii.

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Many urban pest management researchers are currently working on alternative methods that could reduce the need for repeated pesticide applications in the urban environment. One promising technique is thermal pest eradication (TPE). In Hawaii, research efforts are being directed at TPE to ensure that it is both a safe and effective alternative to conventional pesticide treatments. Our research has uncovered some interesting aspects of this process.

How TPE Works

TPE is an urban pest management tool that uses heat to control arthropod pests. Aside from the use of heat for stored-product pests, the primary targets at this time are structural pests, particularly drywood termites. The premise of TPE is based on research conducted by Dr. Walter Ebeling (1994), who arrived at the general formula of 120 degrees Fahrenheit for 30 minutes. This combination of temperature and time is reportedly lethal to almost all insect life, including termites, and is said to include a reasonable margin of safety. To achieve this, the TPE process uses large gas space heaters that blow heated air into a structure to raise and maintain the ambient temperature of the structure between 150 and 170 degrees Fahrenheit for a period necessary to reach the suggested formula in the infested wood. TPE is typically done in a spot treatment fashion, in which the extent of the drywood termite infestation is first determined and then heat applied to the areas that actually contain the infestation. This is unlike fumigation, which requires the whole structure to be covered. In Hawaii, where the tropical conditions are similar to those of Florida, a typical TPE scenario would involve heat being applied to those rooms of a home where evidence of drywood infestation exists.

TPE has a number of selling points over the existing drywood termite management techniques of fumigation and chemical spot treatments. Like spot treatments, it is cheaper than tenting an entire structure for fumigation. At the same time, it is effective over a larger area than chemical spot treatments. TPE is also comparatively quick. Unlike fumigation, it can be done in a single day and the homeowner can return to the home almost immediately after the treatment, without any aeration period. With the public clientele concerned about pesticide use, one of TPE's greatest selling points is the fact that it is "environmentally friendly," there are no pesticides or toxic chemicals used.

Conducted Research

The research that supports TPE used combinations of time and temperature to assess insect mortality. Forbes and Ebeling (1987) placed insects into ovens at constant temperatures, kept them there for specific periods of time and then evaluated mortality.

Our research is directed toward evaluating the use of TPE in the state of Hawaii. Initially, experiments were designed to clearly define the temperature mortality of the West Indian drywood termite (*Cryptotermes brevis*), the principal drywood termite pest in Hawaii. Groups of late instar nymphs were placed in an oven at various temperatures for specific time intervals, and mortality was assessed at 24 hours following removal from the ovens. Our results closely resembled those reported by Forbes and Ebeling (1987). Further research, however, produced mortality values that caused some initial concerns about the potential of TPE.

Factors Affecting Efficacy

Our examination of the entomology literature indicated that most temperature mortality results were reported in the form of critical thermal maxima (CTMax) or upper lethal limits (ULL) (Sponsler and Appel 1991). These values were generated in a process where the test insects were subjected to a specific temperature *rate* of increase, as opposed to a specific *constant* temperature as was reported in the publications used to support TPE. In these CTMax/ULL experiments, termites were placed in test chambers at given ambient "room" temperatures (80 to 86 degrees Fahrenheit), which were then raised at a given rate (usually 1.8 degrees Fahrenheit per minute) until cessation of movement (torpor) was achieved. After the temperature was noted, the insects were removed from the chamber and kept at room temperature until

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Unlike fumigation, TPE is typically done in a spot-treatment fashion and does not require that the whole structure be covered.

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mortality was later assessed. The highest temperature at which termites recovered was termed a "CTMax" and the lowest temperature at which death occurred was termed a "ULL."

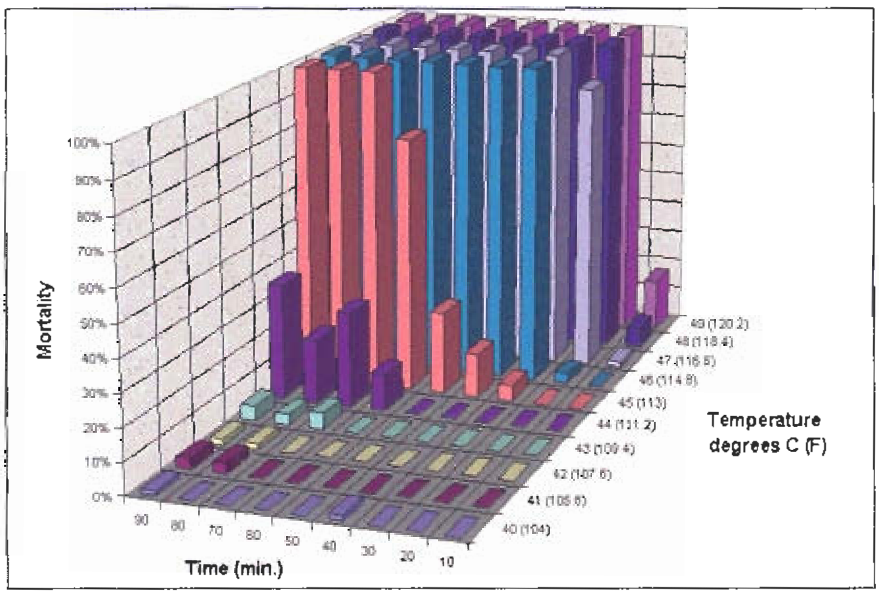
Initial attempts to duplicate these experiments with *C. brevis* generated some extremely high values. In preliminary experiments, complete recovery of *C. Brevis* nymphs that had been exposed to temperatures in excess of 129 degrees Fahrenheit was observed, and, in one particular instance, to a temperature of 142 degrees Fahrenheit at a rate of 2.16 degrees Fahrenheit per minute (starting temperature was 86 degrees Fahrenheit). Further review of the literature revealed that rate is an extremely important factor in heat stress mortality. Pioneering research conducted on cold-blooded vertebrates such as fish and lizards indicated that an intricate relationship exists between body temperature and the temperature of the environment (Fry 1967). Unlike mammals, many cold-blooded organisms (insects included) are at the mercy of highly variable environments and, thus, have various adaptations for dealing with the ever-changing temperature extremes. These adaptations are manifested over different time scales. If climatic temperature increases over a developmental period of months or years, a given insect may gradually acquire the ability to tolerate greater and greater extremes of temperature. This is termed "acclimatization." Likewise, over smaller time scales of days, hours or minutes, insects may also be able to overcome temperature stresses. This short-term adjustment is termed "acclimation."

At rapid rates of temperature increase, it is assumed that insects cannot acclimate fast enough to overcome the heat stress and will die at a lower temperature than if the temperature was raised very gradually. Slower rates would allow them enough time to make physiological adjustments. Likewise, in a temperature mortality experiment, where temperature is changed instantaneously (from room temperature to the given treatment temperature), one can assume that test insects have little or no opportunity to adjust and, thus, will die at lower temperatures than if given a warm-up period—as would be the case during CTMax mortality experiments or a real TPE session. Our research at the present time is focused on characterizing the rates of temperature increase present during actual TPE procedures and how these rates may affect the West Indian drywood termite.

Rates in the Field

To examine TPE temperature increase rates, we collaborated with Certified Pest Control and Fumigation Inc., the only company currently doing structural TPE treatments in Hawaii. For the pest control crew, a typical TPE session involves analyzing how the treatment will be applied to the affected area, covering possible sources of heat loss and other factors, while our work involves choosing sites in the structure to place several temperature thermistor probes, devices made from solid semiconductor materials. The probes are placed in locations that are likely to demonstrate the greatest extremes in temperature. Wood core probes may be placed in the largest and smallest wooden members, at the highest and lowest levels in the treatment area or in locations that border untreated areas. One or two probes are reserved for ambient readings in worst-case areas or those areas bound to experience the lowest temperatures.

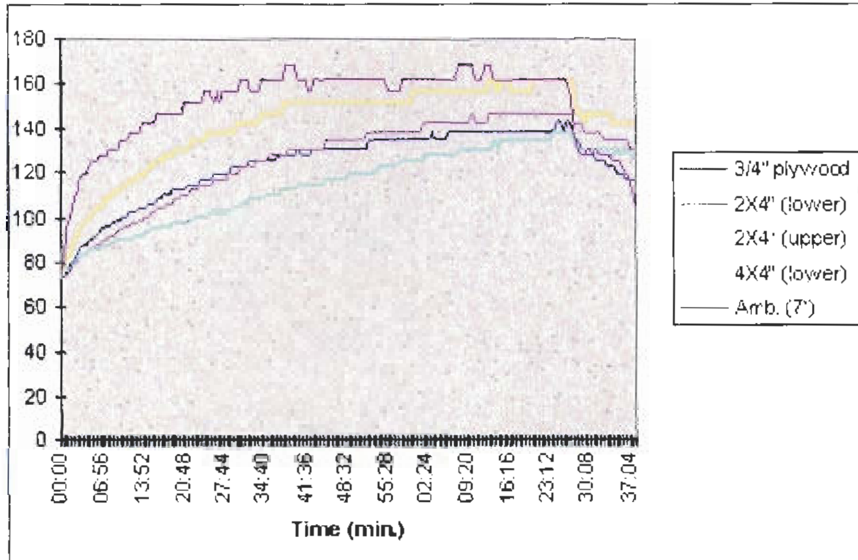
Temperature data collected during TPE sessions on the Big Island of Hawaii indicated a great deal of variability among the various thermistor probes in the structures. Calculated rates of temperature increase were also highly variable, and ranged from 0.16 degrees Fahrenheit per minute in a six-inch by six-inch beam to 1.9 degrees Fahrenheit per minute for a two-inch by four-inch stud.



Mortality of Incisitermes immigrans nymphs placed in an oven at constant temperatures over various time intervals.

Required Temperatures

In the laboratory, temperature mortality experiments are still in progress. The upper lethal limit (ULL) of *C. brevis* nymphs has been calculated to be 135.5 degrees Fahrenheit at a temperature rate increase of 1.08 degrees Fahrenheit per minute. Of particular interest at this point are the upper lethal limits at slower rates, which are those rates that could allow termites to acclimate and, thus, possibly survive the suggested treatment formula of 120 degrees Fahrenheit for 30 minutes. Laboratory simulations of TPE treatments have also been done with *C. brevis.* We used 1.08 degrees Fahrenheit per minute and 2.16 degrees Fahrenheit per minute rates of increase to raise the temperature of the test chamber to 120 degrees Fahrenheit and maintained it for a period of 30 minutes. So far, all of these simulations have produced 100 percent mortality of the test animals. At these rates, it appears that the TPE formula is effective because of the length of time at which the final temperature is held. However, our research has shown that the margin of safety may not be as great as was initially assumed from early mortality studies. We are continuing research to improve the TPE technique by simulating the conditions actually present during real-world pest control treatments. ■



Temperature data collected in Kailua-Kona, Hawaii, during a thermal pest eradication procedure.

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