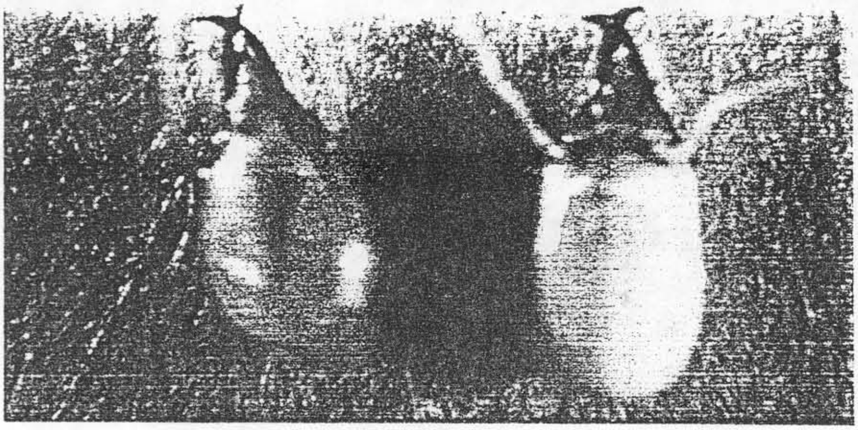

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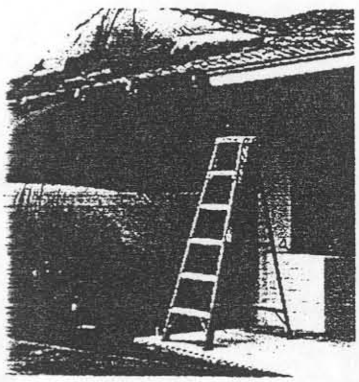

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The first recorded appearance of a new subterranean termite, *Coptotermes havilandi*, is discovered in Miami, Fla. Photo courtesy of Dr. Nan-Yao Su, University of Florida Fort Lauderdale Research and Education Center, Fort Lauderdale, Fla.

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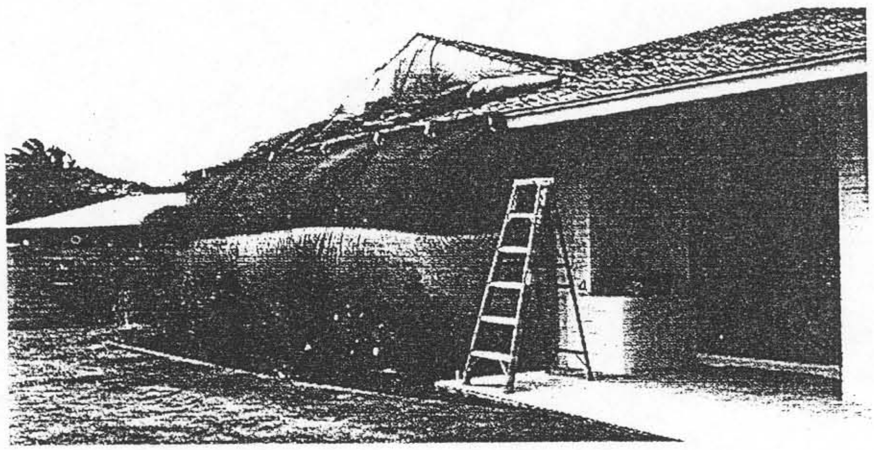
Cooking Termites
in the Aloha State

The state of thermal pest eradication in Hawaii.

BY R. JOSEPH WOODROW AND J. KENNETH GRACE

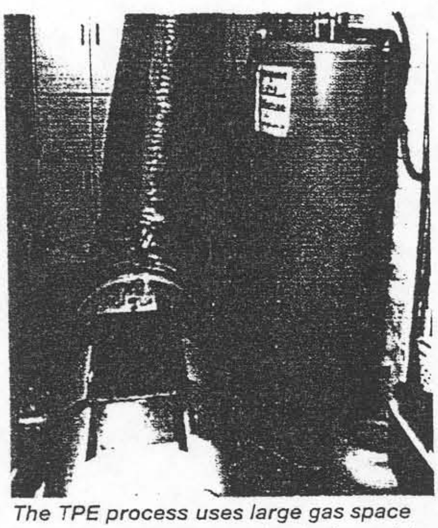


Unlike fumigation, TPE is typically done in a spot-treatment fashion.

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 TPE process uses large gas space heaters to raise and maintain the ambient temperatures in a structure.

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.

Thermal pest eradication 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.

The research that supports TPE used combinations of time and temperature to assess insect mortality.

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Thermal Pest Eradication

BY DR. WALTER EBELING

This letter is addressed to people who have demonstrated their commitment to the protection of an environment we all share and which is under ever-increasing pressures as a result of the population explosion and the avalanche of new synthetic chemicals to which it is subjected, about 6,000 annually in the United States alone. A major aspect of environmental concern is the effect of pesticides on public health.

The Clinton Administration, including the Environmental Protection Agency (EPA), the U.S. Department of Agriculture (USDA) and the Food and Drug Administration (FDA), initiated a shift in the government's approach to pesticide regulation and has committed itself to real reduction in pesticide use. The three agencies will work in concert with pesticide users to help develop and implement improved and safer methods of pest management. In one of the most extensive interagency projects undertaken in recent years, the Pesticide Use Reduction Initiative aims to develop a comprehensive program of regulatory and non-regulatory efforts to reduce the use of pesticides that pose unacceptable risks to humans and their environment, and to encourage alternative practices. The following is a discussion of such an alternative.

Thermal Pest Eradication (TPE) is a patented process, currently used principally for eradicating wood-infesting insects, such as drywood termites (*Incisitermes* and *Coptotermes*). It is not only effective, but also environmentally benign. The use of heat in pest control takes advantage of the facts that insects have very little tolerance for temperatures above or below their normal range in nature. We obtained a complete kill of drywood termite nymphs, confined in petri dishes, in 33 minutes at 120 degrees Fahrenheit and in six minutes at 130 degrees Fahrenheit. Protected in their galleries, it takes much longer, of course. Heat must first penetrate the wood termites inhabit. TPE can be used against any wood-infesting species (we have used it effectively against powderpost beetles).

While eradicating drywood termites with TPE, the technician generates hot air in a mobile convection heater burning propane gas. The heater remains outside the building. It contains an electric fan that blows the heated air into the infested building, or the infested part of it, via flexible, collapsible ducts.

Tarps are suspended from the roof line to facilitate the heating of the outer wall from both the outside and the inside. Unlike fumigation with poison gas, it is not necessary to pull the tarp over the entire roof. This eliminates the need for walking on the roof and causing damage, which is, particularly important in the case of tile roofs. Powerful electric fans distribute the hot air uniformly throughout the treated area. Sensors in various areas keep the technician informed on temperatures in the centers (cores) of the wood members the technician believes will be the last to be heated to the desired temperature, 130 degrees Fahrenheit for at least one hour.

Air temperature may reach 170 degrees Fahrenheit, not enough to cause structural damage, but enough to damage heat-sensitive items such as computers, plastic, artwork, antique furniture and house plants. Such items are either removed or covered with thermal blankets during the treatment.

Benefits

A termite operator who does both heat treatment and fumigation, and who has heat-treated more than 1,000 homes in the past three years, reports only five failures, all during his early learning period. This .05 percent failure rate may be compared with a failure rate of five percent to 15 percent with fumigation. Moreover, TPE results in greater satisfaction. Treatment is not likely to last longer than six hours, and occupants of a heat-treated house can reoccupy the house on the same day it was treated. Occupants of a house fumigated with Vikane (sulfuryl fluoride) must stay out of the house for two days. All occupants of a condominium must leave, even if only one or two units of the building are infested. With heat, a technician can treat an entire house or any part of it. Even in a single room, the technician can largely confine heat to one wall if he or she wishes to do so, using easily installed "air curtains" to confine the hot air to an infested area while increasing the temperature in the remainder of the room by only two or three degrees.

Continuously increasing costs of fumigation, and increasing restrictions on its use, have left some fumigators dispirited. New regulations make it necessary for the fumigator to read a long directive, warning occupants of the building of the possible hazards and what must be done to eliminate or mitigate them. Fumigators must confirm that the fumigant is present in a concentration of no more than three parts per million (ppm) when occupants of a fumigated house are allowed to return.

According to one fumigator in California, however, the concentration may be difficult to confirm. He said he measured a Vikane gas concentration of five ppm in a home, then closed the house for two days. He returned to find a general concentration of 25 to 30 ppm, but 250 ppm under a sofa and similarly high concentrations in some other areas of stagnant air. Gas in wall voids and other dead-air spaces, and absorbed into items such as wood, mattresses and cushions, is not going to leave immediately as soon as doors and windows are opened and one or more fans are activated.

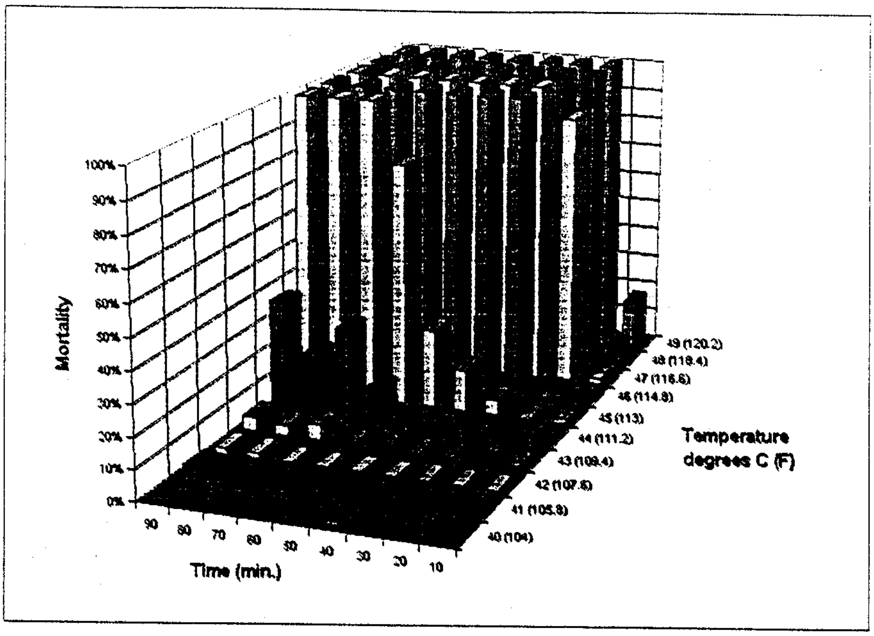
The rate at which a fumigant leaves a house is also influenced by insulation. In some houses, the inner walls are insulated as well as the outer walls. This great area of adsorption and absorption retards the rate at which a fumigant leaves the premises. Insulation installed in the attic is another gas sink. It may be a foot deep in some places if blown into the attic.

Movement of gas from the outer wall voids to the outside is also retarded by "house wrap," a permanent plastic barrier, as well as by stucco and heavy spray coatings. Any insulation that prevents outside air from moving into a house will likewise prevent gas from moving to the outside. The large quantity of fumigant that is trapped in a house will slowly escape into the living space, to maintain a significant concentration there for weeks and traces of it for months.

The fumigants used in termite control are nerve poisons. Also, every year a few burglars, and indigents seeking shelter, die as the result of entering fumigated houses before the tarps are removed.

In California, people must now stay out of a fumigated house for three days, if methyl bromide is used as the fumigant. Moreover, methyl bromide will probably soon be banned entirely. The EPA aims for a phase-out of production and consumption of methyl bromide by the year 2001. This will result in the loss of the only gas that can be effectively used to control powderpost beetles. □

Dr. Walter Ebeling is professor emeritus, entomology, from University of California Los Angeles and Riverside.



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

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) (Figure 1). 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 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

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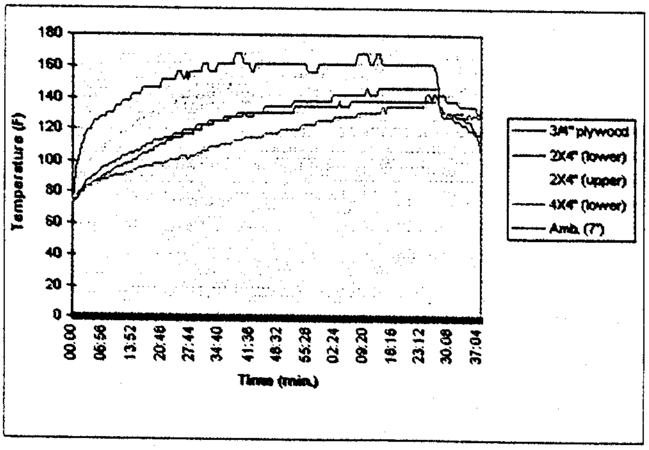

Temperature data collected in Kailua-Kona, Hawaii, during a thermal pest eradication procedure.

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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.

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. **PC**

R. Joseph Woodrow is a Ph.D. candidate at the University of Hawaii. J. Kenneth Grace is an associate professor of entomology in the College of Tropical Agriculture and Human Resources, University of Hawaii.

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