PROCEEDINGS

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Thermal Mortality of Hawaiian Subterranean and Drywood Termites (Isoptera: Rhinotermitidae, Kalotermitidae)

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Introduction

The purpose of this study was to determine the thermal thresholds for termite species occurring in Hawaii. The critical thermal thresholds of insects are of particular interest in Hawaii because of the economic damage caused by termites, influence of tropical temperatures on termite distribution in the islands, and potential application of modified temperatures in thermal pest eradication or TPE. The TPE method as outlined by Ebeling (1994) involves tarping a structure as in gas fumigation and pumping heat into it to achieve and maintain an internal ambient temperature of between 145° to 150°F (63°-66°C). These ambient temperatures are usually maintained for a period necessary for the internal wood temperatures to exceed 120°F (49°C) for a minimum 30 minute duration.

The thermal relationships of a number of insect taxa have been reported, including cockroaches, blister beetles, imported fire ants, earwigs and termites. Most of these results have been in the form of critical thermal maxima (CTMax) and minima (CTMin). Critical thermal maxima range from about 109° to 124°F (43°-51°C) for most insect species. Because of discrepancies in the studies utilizing the CTMax/Min methodology, we adopted a more conservative "dose-mortality" approach in which we measured termite mortality at specific temperature-time intervals. We generated three dimensional matrices of temperature, time and mortality for two Hawaiian termite species, *Coptotermes formosanus* Shiraki (Rhinotermitidae) and *Incisitermes immigrans* (Light) (Kalotermitidae).

Methods

Coptotermes formosanus

Formosan subterranean termites were collected in wooden traps on the Manoa campus of the University of Hawaii in Honolulu. Time and temperature were varied over the ranges of 10 minutes to 90 minutes and 40°C to 49°C, respectively. The experimental units consisted of covered 100 x 20 mm glass petri plates which contained 50 workers (pseudergates) each. Three replicate units were chosen at random from a pool of all possible units to receive a particular time-temperature combination; all treatments at a given temperature were run concurrently. Petri plates were placed in an incubator (Accuracy: ±0.5°C from 40°C to 50°C) at ca. 5% relative humidity at time zero and quickly removed at their respective treatment times over ten minute intervals extending up to ninety minutes. The number of dead, moribund and live individuals were then counted and a single piece of filter paper was placed in each petri dish along with 1 ml of distilled water. The plates were then covered and placed in an incubator set to 28°C (±0.5°C) for a period of 24 hours at which point the number of dead, moribund and live individuals were again assessed. The values reported here represent 24 hour mortalities.

Incisitermes immigrans

This species was examined in the same manner as *C. formosanus* with some minor modifications. Test subjects were late instar nymphs from several individual colonies taken from dead standing wood collected near the University of Hawaii at Manoa campus. Individual colonies extracted from wood samples were placed in individual plastic containers along with tongue depressors as a food source and a number of pieces of filter paper soaked with distilled water. The covered containers were placed in an incubator set to 28°C and the colonies allowed to acclimate for a period of no less than 24 hours prior to testing. Because of the relative difficulty in obtaining large numbers of this species, treatments consisted of three replicates of twenty nymphs each placed in smaller (60 X 15 mm Kimax) glass petri plates. Treatments were conducted as previously described for *C. formosanus*, with mortality assessed 24 hours after removal from each particular time-temperature regime.

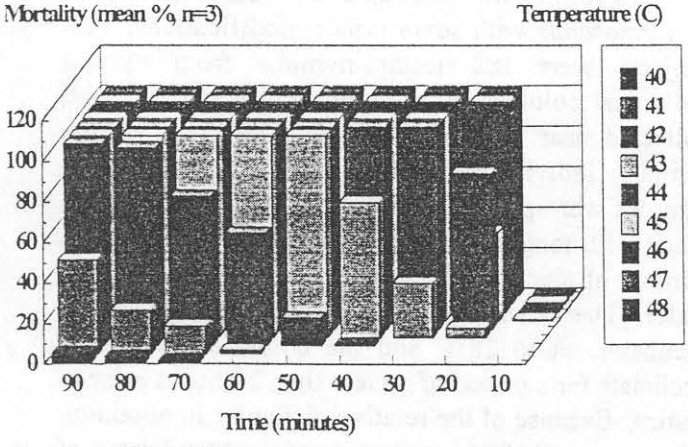
Results and Discussion

Figures 1 and 2 present the mean (n=3) mortalities for each termite species under each of the times and temperatures. These charts display a wide temporal spectrum of the effects of temperature on termite mortality. At the low end of the temperature scale, an upward trend in the mortality of *C. formosanus* can be seen at 40°C from 70 minutes upward; while with *I. immigrans*, this same trend is apparent at a significantly higher temperature (43°C) from 60 minutes. The lowest extreme of total (100%) mortality is reported for *C. formosanus* at temperatures as low as 42°C at 80 minutes and for *I. immigrans* at 45°C and 70 minutes.

It has been demonstrated with a number of insect species that CTMax as well as other physiological parameters are correlated with habitat; xerically adapted insect species seem to have higher CTMax values. The data generated on the two Hawaiian termite species is thus consistent with the biology of these species; ie., *C. formosanus* is adapted for a subterranean habitat while *I. immigrans* typically occupies hot xeric above-ground sites.

Over equal time intervals, the thermal thresholds reported here for *C. formosanus* are consistently lower than the CTMax values reported previously. Sponsler and Appel (1991) reported the CTMax for *C. formosanus* workers to be 46.3°C and the upper lethal

Figure 1. *Coptotermes formosanus* thermal mortality.

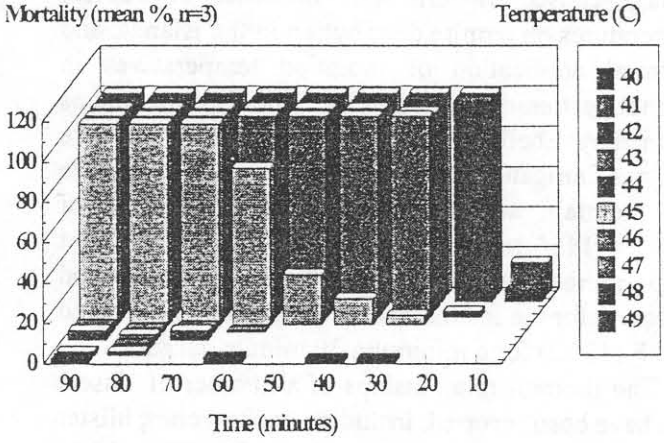


Control mortality = 1%

limit (ULL) to be 48.0°C. In that study, elapsed times ranged from 20 to 30 minutes [time elapsed = (CTMax-initial temperature) X (1°C/min)]. For 20 to 30 minute exposures at constant temperatures, in our study, 100 % mortality was produced in the range of 44° to 46°C for *C. formosanus*. The slight discrepancy between CTMax data and our results could be attributed to the cumulative effects of lower temperatures in the CTMax test scenario being less than that of a constant temperature or very rapid initial increase in our test. Thus, CTMax values would be slightly inflated over true lethal temperature thresholds.

No previous studies have reported CTMax for *I. immigrans*. However, the CTmaxima for *Incisitermes fruticavus* Rust and *Incisitermes minor* (Hagen) were reported to be in the range of 51° to 53°C. At equal elapsed times in our study, 100% mortality was

Figure 2. *Incisitermes immigrans* thermal mortality.



Control mortality = 5%

achieved with *I. immigrans* at 48° C and 46° C for 20 and 30 minute exposures respectively.

Despite the differences between the thermal maxima reported here and CTmaxima reported from previous studies, our threshold temperatures fall well within the bounds of the temperature exposure recommended for commercial termite control [120°F (49°C) for 30 minutes] (Ebeling 1994). At this temperature we achieved complete mortality of both *C. formosanus* and *I. immigrans* in 20 minutes.Tests are continuing with other termite species.

Selected References

Ebeling, W. 1994. The thermal pest eradication system for structural pest control. The IPM Practitioner. 16(2): 1-7.

Sponsler, R. C. & A. G. Appel. 1991. Temperature tolerances of the Formosan and Eastern subterranean termites (Isoptera: Rhinotermitidae). Journal of Thermal Biology 16: 41-44.