High-Temperature Tolerance in Two Species of Subterranean Termites from the Sonoran Desert in Arizona[1,2]

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Field studies on the foraging activity and behavior of *Heterotermes aureus* (Snyder) and *Gnathamitermes perplexus* (Banks) have revealed that these termites occasionally work at temperatures close to 50°C. Temperature is probably the major factor regulating their activity in plant debris on the soil surface, with moisture also having a regulatory effect in upper soil levels. Their ability to work at such high temperatures led us to this brief investigation of their upper survival thresholds.

Materials and Methods

Large foraging groups of both species were collected from July to September at the study site on the Santa Rita Experimental Range, 40 km S of Tucson, Ariz., at an elevation of 950 m. They were maintained in an incubator at 25±1°C on fine sand, with stiff agar as a moisture source. Food consisted of filter paper (*Heterotermes*) or dry cow chips (*Gnathamitermes*).

Upper survival thresholds were determined by warming 80 termites of each species (8 groups of 10) from room temperature (ca. 27°C) to successively higher temperatures for short periods, returning them to 25°C and checking survival. Groups were held separately in a plastic tray divided into compartments (3×5.5×2.5 cm.) floored with lens paper. Half the termites (4 groups of each species) were kept in a desiccator containing Drierite®, the other half in a desiccator containing a water-soaked paper towel. The relative humidities varied from about 40%, when the termites were transferred from laboratory air, down to ca. 8% in the dry desiccator, and up to ca. 98% in the humid one at the end of each test. A thermometer (accurate to ±1°C) was so placed in each desiccator that the air temperature just above the termites could be read through the glass door of an incubator. Each test involved short exposures of the termites in an incubator held at 55±1°C. Several runs were made to successively higher temperatures, the last to 54°C where survival decreased considerably. At the end of each test the trays were removed from the desiccators, and the condition of the termites was noted while they were cooling at room temperature. They were then held in desiccators at 25°C and 100% RH, along with unexposed control groups, for determination of survival during the next 48 h. None of the control termites died under these conditions.

Sixteen separate samples for each species (160 termites) were warmed to 53°C, avg 30.5 min each, and 32 samples for each species (320 termites) to 54°C, lasting 30–37 min each. Although such temperatures were not taken, it is possible that the termites at the higher humidity reached higher internal temperatures, because they were cooled less by evaporation. However, there were no significent differences (0.05 level) in survival between the groups at each relative humidity, probably because of such short exposures. The data for both groups were therefore combined. Exhaustion of water reserves was also unlikely at the time intervals used. The data were analyzed (using Student's "t" statistic) by comparing 2 sample means with unpaired observations and equal variances.

Results and Discussion

The experiments were designed to simulate a natural foraging situation in which termites travel upward from deep, relatively cool galleries to work, presumably for short periods, in superficial plant debris where summer temperatures commonly reach 50°C. It seems likely they either do not encounter, or tend to avoid, sudden

[1] Isoptera: Rhinotermitidae, Termitidae.

[2] Journal Paper no. 2053 of the Arizona Agricultural Experiment Station. The work on which this report is based was carried out as part of the U.S./I.B.P. Desert Biome, and was supported (in part) by National Science Foundation Grant no. GB-15886. Received for publication 12 Feb. 1973.

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changes to higher temperatures. When exposed workers of *Gnathamitermes* are suddenly moved from room temperature to 55°C they promptly evacuate the hind gut, which reduces survival as a result of mass entrapment and cuticular damage. This behavior is rare in *Heterotermes*. Acclimatization was not attempted because long-term culturing has been unsuccessful.

Survival of both species was high after warming from 27 to 53°C lasting for ca. 30 min (Table 1). The data show also that the survival of *Heterotermes* was abruptly reduced after warming to 54°C. Both species are obviously capable of working and surviving for short periods at ambient temperatures somewhat above 50°C. Of the 2, *Gnathamitermes* has a slightly higher heat tolerance. These tolerances appear to be reflected in their foraging behavior. *Gnathamitermes* forages widely on the surface under and within cavities of dead wood and dung, and on all types of dry, tender vegetation, generally removing only superficial fibers or very fine plant parts. It often works under thin soil sheeting which it builds over dead plant material. *Heterotermes* works almost exclusively within bits and larger pieces of dead wood. At high temperatures it does not seem likely that individual workers of either species spend much time at the surface, probably remaining only long enough to exchange a load of soil for a bit of plant material.

Intragallery temperatures have not been measured, but the fact that both species commonly pack their workings with soil, as do many other termites (Lee and Wood 1971), suggests that this habit may contribute to the reduction or stability of temperature within these cavities. After a year of intensive field study we have established foraging limits of *Heterotermes* between 7.6 and 47.0°C, and of *Gnathamitermes* between 9.0 and 49.0°C (extremes measured in a series from under objects on the surface to a soil depth of 15 cm). Lee and Wood (1971) reviewed the literature dealing with temperature within nests and workings, mainly of mound builders. We are not aware of any reports of foraging activity at temperatures even approaching 50°C, although it may be commonplace, especially in other desert regions and in the tropics.

Table 1. — Survival of groups of 10 termites when warmed from 25 to 53°C for 30.5 min, and to 54°C for 33–37 min.

Termite	Mean ± $CI_{95\%}$ at 53°C[a]	Mean ± $CI_{95\%}$ at 54°C[b]
Gnathamitermes	7.06±1.45	5.00±1.10
Heterotermes	8.44±1.06	1.97±0.94

[a] Based on 16 groups; differences not significant at the 0.05 confidence level.
[b] Based on 32 groups; differences significant at the 0.001 confidence level.

REFERENCE CITED

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Reprinted from the
ENVIRONMENTAL ENTOMOLOGY
Volume 2, Number 6, pp. 1122–1123, December 1973