FACTORS AFFECTING TERMITE RECRUITMENT TO BAITS IN LABORATORY AND FIELD STUDIES

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Abstract - A weak link in the implementation of effective termite baiting techniques is reliable recruitment of termite foragers to baits. Little is known about how termites locate food sources, but many factors may influence whether foragers find and recruit to a given bait. These include the abundance and palatability of the bait relative to alternate foods in the habitat, chemical directional clues to the location of food in the soil environment, and the presence of predators and termite competitors at the bait site. We have investigated these factors in the subterranean termite *Reticulitermes* (Isoptera: Rhinotermitidae) over the past five years in laboratory and field studies in Virginia. In the laboratory, termites recruited in higher numbers to substrates drenched with solutions of sucrose and yeast or urea than to water-drenched substrates. In field studies, more termites occupied baits covering drenches of sucrose + yeast or urea solutions than baits covering water drenches. Some baits contained ant predators. *Reticulitermes flavipes* and *Reticulitermes virginicus* usually fed on separate baits, but once *R. flavipes* appeared to be displaced by *R. virginicus*. These results suggest that numerous bait monitoring stations should be placed near structures to ensure that all local colonies have an opportunity to sample baits. Continued experimentation with drenches is likely to yield a recipe that reliably draws termite foragers to baits.
Key words - Foraging, *Reticulitermes*, sucrose, urea

INTRODUCTION

A promising new focus in termite control involves baits that deliver toxicants to termites (French, 1994). The objective is to draw termite foragers to a palatable bait laced with toxicant; foragers are expected to distribute the toxicant to nestmates, resulting in the elimination or suppression of the colony. The weak link in this chain is the recruitment of termites to the bait. Factors that may affect termite recruitment include the amount of bait and its palatability relative to other foods in the habitat, chemical directional cues to the location of the bait in the soil environment, and the presence of predators and termite competitors at the bait site.

No reliable techniques have been developed to ensure that termites locate baits, because little is known about how termites find food in nature. One possibility is that foragers follow subterranean concentration gradients of chemicals leached from rotting wood. We examined this idea by testing termite response to chemicals and their leachates in laboratory and field tests. We focused on solutions containing sucrose and yeast and urea (Waller, 1996). Sucrose is found in decomposing wood (Anderson, 1962), and yeasts are widespread in woody debris and soil. Urea occurs in fungi (Martin, 1979), which are frequently consumed by termites in decayed wood (Waller *et al.*, 1987).

MATERIALS AND METHODS

Termite collections

Reticulitermes (Rhinotermitidae) colonies were collected from southeastern Virginia. Both *Reticulitermes flavipes* Kollar and *Reticulitermes virginicus* Banks were collected and used in experiments. Termites were maintained in the host log in the laboratory at 22 °C up to 24 h prior to experiments.

Sucrose and yeast

Each laboratory test unit consisted of three connected clear plastic chambers, each 12.5 cm x 10 cm x 1.0 cm. Clear plastic tubing connectors allowed free movement among chambers. We placed 50 cc vermiculite and 25 ml solution in each chamber. The central chamber and one side chamber contained

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distilled water, and the other side chamber contained 1% (w/v) yeast in 1% (w/v) sucrose solution. Two hundred termite workers and four soldiers were added to the central chamber. After 3 d at 22ºC, numbers of termites in each chamber were counted. Three colonies (two *R. flavipes* and one *R. virginicus*) were tested with two replicates per colony.

Field experiments were performed at Old Dominion University's Blackwater Ecological Preserve (BEP), a 130 hectare pine forest in Zuni, Virginia. Both *Reticulitermes flavipes* and *R. virginicus* are common at the site. Three parallel 130 m transects were set 10 m apart with baits placed every 10 m (total 42 baits). Baits consisted of rolled cardboard secured with a pine stake and covered with a plastic pot. We poured 4 l of solution under each bait, alternating drenches of distilled water and solutions of 1% (w/v) yeast in 3% (w/v) sucrose solution. Baits were checked for termites at 1, 4 and 6 weeks later.

Urea

Laboratory experimental units consisted of a central 40 cc round plastic chamber attached by clear plastic tubing to four identical chambers. The central chamber was filled with 30 cc sand and 15 ml distilled water; the attached chambers contained 40 cc sand and 10 ml of either 1% urea solution (2 chambers) or distilled water (2 chambers). We placed 20 termites in the central chamber and allowed them to forage through the tubing and into the attached chambers. Numbers of termites entering the urea- or water-drenched chambers were recorded at 3, 6, 9, 12, 15, 30 and 1,440 min. Ten colonies (five *R. flavipes* and five *R. virginicus*) were tested with 3 replicates per colony.

The field experiment was performed at BEP, at a different location from the sucrose experiment. Two sets of transects were established, each with five parallel 100 m transects set 10 m apart, with baits (a pine stake next to a pine shim pack) placed every 10 m (total 100 baits). We poured 4 l of solution under each bait, alternating drenches of well water and 1% urea solutions. Baits were checked for termites at 4, 5, 6 and 7 weeks.

Data analysis

Laboratory data were statistically analyzed using analysis of variance. Field data were not analyzed due to the low numbers of termites present in the baits.

RESULTS

Sucrose and yeast

In the laboratory experiment significantly greater numbers of termite workers recruited to the sucrose and yeast chambers than remained in the central chamber or recruited to the water-drenched chambers (ANOVA, $F = 27.273$, $p = 0.0001$). There were also significantly greater numbers of soldiers in sucrose + yeast chambers than in the others (ANOVA, $F = 24.5$, $p = 0.0001$) (Table 1). *R. flavipes* and *R. virginicus* showed similar responses.

Table 1. Mean + SE numbers of termite workers and soldiers in the central chamber, and chambers drenched with 1% (w/v) sucrose and 1% (w/v) yeast solution or distilled water. Each unit initially had 200 workers and 4 soldiers introduced to the central chamber. Units were maintained for 3 d in the laboratory at 22ºC.

	Treatment		
	Sucrose and yeast	Central	Water
Workers	119.3 ± 14.6	49.3 ± 11.6	18.8 ± 2.3
Soldiers	2.5 ± 0.5	0.8 ± 0.8	0.2 ± 0.2

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Table 2. Number of baits occupied by termites after 1, 4 or 6 weeks in field experiment. Baits covered drenches of 4 l of either 3% (w/v) sucrose and 1% (w/v) yeast or distilled water.

	Bait treatment	
Week	Sucrose and yeast	Water
1	11	4
4	11	9
6	10	11

Table 3. Mean ± SE number of termites entering chambers drenched with solutions of 1% urea or distilled water over time. Twenty termites were introduced in a central chamber and observed over 1,440 minutes. Ten colonies with three replicate units per colony were tested.

	Treatment	
Minutes	Urea	Water
3	1.1 ± 0.6	0.1 ± 0.0
6	1.3 ± 0.7	0.2 ± 0.1
9	1.6 ± 0.8	0.3 ± 0.1
12	2.0 ± 0.8	0.3 ± 0.2
15	2.0 ± 0.7	0.6 ± 0.3
30	3.2 ± 1.2	1.2 ± 0.4
1,440	6.7 ± 1.1	6.2 ± 1.3

Table 4. Number of baits occupied by termites after 4, 5, 6, 7, and 8 weeks in field experiment. Baits covered 4 l drenches of either 1% (w/v) urea or distilled water.

	Treatment	
Week	Urea	Water
4	1	0
5	1	1
6	1	1
7	4	1
8	2	1

After one week in the field experiment, eleven sucrose + yeast baits contained termites, and four water baits had termites. In weeks 4 and 6, however, the numbers of sucrose + yeast baits and water baits with termites were similar (Table 2). Over the six-week period, a total of 13 sucrose + yeast-drench baits and 13 water-drench baits were occupied by termites. Four sucrose + yeast-drench baits contained *R. flavipes* initially (one of these was taken over by *R. virginicus*), and *R. virginicus* occupied 10 baits. Two water-drench baits contained *R. flavipes*, and 11 contained *R. virginicus*.

Urea

In the laboratory experiment significantly greater numbers of termites recruited to the urea-drenched chambers than to the water-drenched chambers (Repeated measures ANOVA, $F = 4.15$, $p = 0.0483$).

Numbers of termites increased in both chambers over time (F = 24.264, p = 0.0001) (Table 3). *R. flavipes* and *R. virginicus* showed similar responses. In the field experiment more urea-drench baits were occupied by termites than water-drench baits, but there was little recruitment to any bait (Table 4). Four urea-drench baits contained termites (three with *R. virginicus* and one with *R. flavipes*), and two water-drench baits contained termites (both *R. virginicus*). Ants were found in two urea-drench baits, one without termites and one with *R. flavipes*.

DISCUSSION

The foraging biology of termites is poorly known (Curtis and Waller, 1997). Our laboratory experiments demonstrated that the subterranean *Reticulitermes* can detect chemcial drenches in the substrate and will move towards both urea solutions and sucrose + yeast solutions. In nature, urea, sucrose and yeast are likely to be encountered by termites in the soil and decayed wood in much lower concentrations than those tested here (Anderson, 1962; Martin, 1979). Whether these chemicals help termites locate natural food sources is unknown. However, our results indicate that urea and/or sucrose and yeast solutions have the potential to draw termites to bait stations. In the field, more baits on urea and sucrose and yeast solution drenches were occupied than baits on water drenches, but the results were not as strong as in the laboratory. Many factors may account for the weaker response in the field. First, termites in a pine forest have an abundance of alternate foods, perhaps more palatable than the treatment solutions. Second, the dense mosaic of chemical traces in soils may have interfered with the termites' detection of the sucrose + yeast and urea solutions. Third, the soil water content at the time of the experiments may have influenced whether or not termites responded to the water drench. During dry seasons, water drenches alone may draw termites to a bait. Fourth, microbial activity in the soil may have altered the chemistry of the solutions.

Ant predators were present in one termite-occupied bait. We have often found ants and termites together in logs and in other bait studies, but ants rarely appear to interfere with termite activity (Waller, personal observation). However, it is possible ants influenced the low number of baits occupied by termites. More baits were occupied by *R. virginicus* than *R. flavipes*, and we noted one instance where *R. virginicus* appeared to take a bait from *R. flavipes*. In laboratory competition experiments (Mathews and Waller, unpublished), *R. flavipes* controlled the bait in some outcomes, and *R. virginicus* controlled the bait in others. These results suggest that baiting regimes should include numerous bait stations so that all local species have an opportunity to sample baits. More research on recipes for drenches and the influence of predation and competition on bait occupation will be valuable in the development of effective baiting programs for termites.

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REFERENCES CITED

Anderson, A. B. 1962. On the chemistry of wood rot. TAPPI 45: 40-60.

Curtis, A. D. and D. A. Waller. 1997. Problems with the interpretation of mark-release-recapture data in subterranean termites (Isoptera: Rhinotermitidae). Sociobiology 30: 233-241.

French, J. R. J. 1994. Combining physical barriers, bait and dust toxicants in future strategies for subterranean termite control (Isoptera). Sociobiology 24: 77-91.

Martin, M. M. 1979. Biochemical implications of insect mycophagy. Biological Reviews 54: 1-21.

Waller, D. A. 1996. Ampicillin, tetracycline and urea as protozoicides for symbionts of *Reticulitermes flavipes* and *R. virginicus* (Isoptera: Rhinotermitidae). Bull. Entomol. Res. 86: 77-81.

Waller, D. A., J. P. La Fage, Gilbertson, and M. Blackwell. 1987. Wood decay fungi associated with subterranean termites in southern Louisiana. Proc. Entomol. Soc. Wash. 89: 417-424.