

# Evaluation of Bait-Toxicants for Suppression of Subterranean Termite Populations

by

Nan-Yao Su<sup>1</sup>

## ABSTRACT

Methods of evaluating the effects of bait toxicant against field populations of subterranean termites are reviewed. To adequately assess the toxic effects of baits on termite colonies, foraging populations should be estimated before and after the application of bait.

## INTRODUCTION

Foraging galleries of the Formosan subterranean termite, *Coptotermes formosanus* Shiraki, may include many nesting structures (main nest and satellite nests) interconnected by tunnels (King & Spink 1969, Li *et al.* 1976). Gallery systems extend for up to 100m for *C. formosanus* (Su & Scheffrahn 1988) and up to 79m for the eastern subterranean termite, *Reticulitermes flavipes* (Kollar) (Grace *et al.* 1989). Damage to houses occurs when termite activity moves above the soil surface (Fig. 1A). Currently, termiticides are applied to the soil to create an impenetrable barrier (by trenching, drilling, injecting, and pre-construction spraying) to exclude soil-borne termite populations from a structure (Fig. 1B). The subterranean termites are, however, likely to continue their foraging activity near the structure, even after the soil is treated with termiticides (Su & Scheffrahn 1988).

Randall and Doody (1934) first reported that arsenic dusts were slow-acting and could be used to reduce the size of colonies of termites. Beard (1974) suggested placing toxic baits in the soil to eliminate established colonies of *Reticulitermes* spp. This is achieved when foragers acquire a lethal dose of a slow-acting toxicant and die after moving away from the toxicant acquisition site (Fig. 1C). If successful, subterranean populations may be

---

<sup>1</sup>Ft. Lauderdale Research and Education Center, University of Florida, IFAS, 3205 College Ave., Ft. Lauderdale, Florida 33314-7700

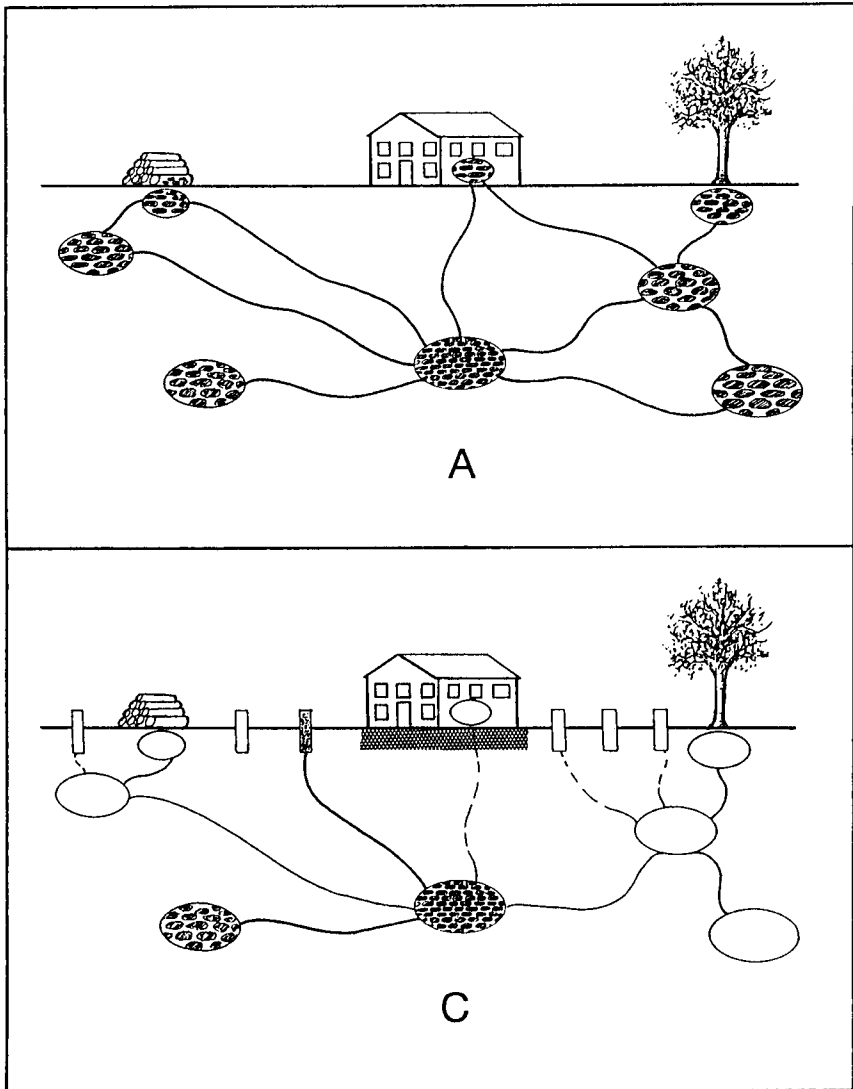
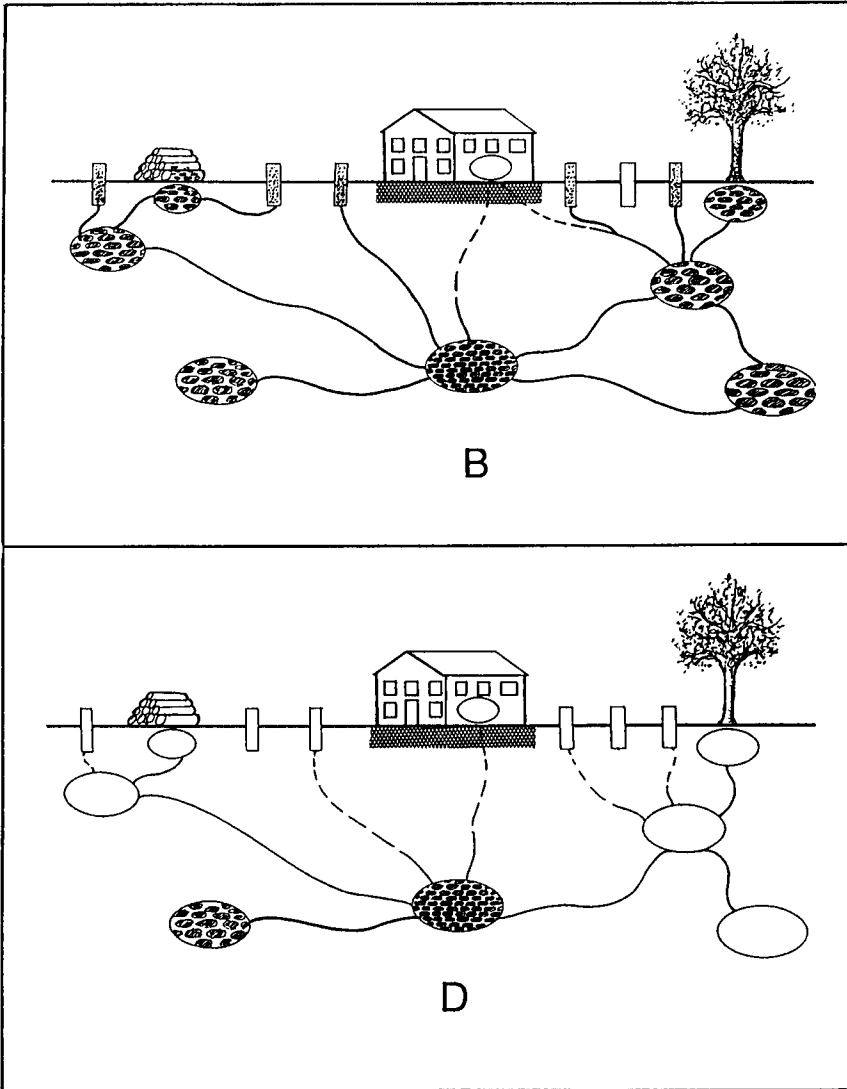


Fig. 1. Subterranean termites construct elaborated gallery systems in the soil and invade houses when the foraging activity moves above the soil surface (A). In addition to the conventional soil treatment beneath a structure (shaded area), bait toxicants can be placed in the ground so that foragers would acquire a



lethal dose of a slow-acting toxicant and die as a result of visiting the toxicant acquisition site (B). Subterranean populations and foraging zone may be reduced to the extent that damage potential to structures, and other wood materials on the soil surface is minimized (C and D).

reduced to the extent that the potential for damage to a structure, and other wood materials on the soil surface, is minimized (Fig. 1D).

## EVALUATION

There are many uncertainties involved in the evaluation of the effects of a bait-toxicant against populations of subterranean termites. Hänel (1983) selected a mound-building termite, *Nasutitermes exitiosus* (Hill), to test the effects of an entomogenous fungi, *Metarhizium anisopliae* Sorokin, in part due to the easy access to the field populations in mounds. Unlike the mound-building termites, the nests of subterranean termites are difficult to locate. Radioisotopes were successfully used to monitor foraging activities of *C. formosanus* (Li *et al.* 1976) and to evaluate mirex baits for control of the Australian subterranean termite, *Macrotermes darwiniensis* Frogg. (Paton & Miller 1980, Spragg & Paton 1980). Large numbers of bait blocks or ground stakes have been placed in the ground to monitor foraging activities of *Reticulitermes* spp. before and after the introduction of a bait toxicant (Esenther & Gray 1968, Esenther & Beal 1974, 1978, Ostaff & Gray 1975, Jones 1988). Presumably, the number of bait blocks or ground stakes attacked by termites (and the extent of damage to each block) would be reduced when a substantial portion of subterranean termite population was affected by the toxicant baits. Gao *et al.* (1985) examined the presence of dead termites after the application of bait at sites previously containing live termites. The lack of termite activity in bait blocks, ground stakes, or at a foraging site, however, may not necessarily be due to the decline of termite foraging activity or to excessive mortality of the termites. Termites may have been repelled by the treatment, or simply shifted their foraging activities to different sites.

Moreover, differences in foraging behavior among subterranean termite species may make it difficult to adequately evaluate results by counting the numbers of bait blocks or stakes attacked. Once a food source is detected, *C. formosanus* tends to concentrate their foraging activity on that particular target, resulting in intense damage to the selected object. *Reticulitermes* spp., on the other hand, tend to distribute their attack on many targets with lower

intensity (Delaplane & La Fage 1989, Su, N.-Y., unpublished data). In urban southeastern Florida, generally only 5-10% of wooden stakes placed in the ground in the vicinity of an infested structure were be attacked by *C. formosanus* even after 5 years (Su & Scheffrahn 1988).

### BAIT STATION

Instead of using wooden stakes driven into ground, bait stations composed of wooden blocks placed underground and surrounded by polyvinylchloride (PVC) collars (17cm diameter by 15cm high), have been used to monitor foraging activity of *C. formosanus* (Su & Scheffrahn 1986). First, wooden stakes were driven into soil near buildings known to have structural damage by *C. formosanus*. When the ground stake was infested by termites, the surrounding soil was removed and the PVC collar was place in the hole to form an underground cavity to house the wooden bait block. Foragers of *C. formosanus* return regularly to the newly placed wooden block in the bait station which provides a semi-permanent access to the underground foraging populations.

**Feeding Preference and Foraging Site Avoidance.** Baits placed in the stations can be easily modified to measure variables such as feeding preference or foraging site avoidance. In one of our field trials for testing a slow-acting toxicant (A-9248, diiodomethyl para-tolyl sulfone) against colonies of *C. formosanus*, we used baits composed of 6 pine (*Pinus* sp.) boards (7 by 13 by 2cm). Three of the boards were vacuum impregnated with acetone only, and the other three were impregnated with a solution of A-9248 (Su *et al.*, unpublished data). Feeding preference of termites was determined by comparing the amount of wood consumed from three acetone-treated boards with the amount from the boards treated with A-9248. A consistently significant reduction in consumption of the toxicant-treated boards would indicate that the termites preferred to feed on untreated wood. In addition to feeding preference, site avoidance can also be monitored by comparing the foraging activity (number of termites collected and total amount of wood consumed) within a single colony between stations receiving toxic baits and those receiving untreated baits. In our field trials with A-9248 baits, *C. formosanus* did not avoid foraging sites containing baits treated with A-9248 at 600ppm.

No consistent feeding preference was detected between treated or untreated boards, and we concluded that baits treated with A-9248 were accepted as much as untreated wood (Su *et al.*, unpublished data).

### FORAGING ACTIVITY AND POPULATION ESTIMATION

Earlier researchers used the number of bait blocks (Esenther & Gray 1968, Esenther & Beal 1974, 1978, Ostaff & Gray 1975) or ground stakes (Jones 1988) attacked by termites (and the extent of damage) to represent the foraging activity when testing bait toxicants against field colonies of subterranean termites. In our field study of A-9248 against *C. formosanus* colonies, foraging activity was monitored throughout application of the bait by measuring the wood consumption and the number of termites collected from the bait stations. The foraging activity of a colony typically declined for 3 to 4 months after receiving toxic baits (Fig. 2).

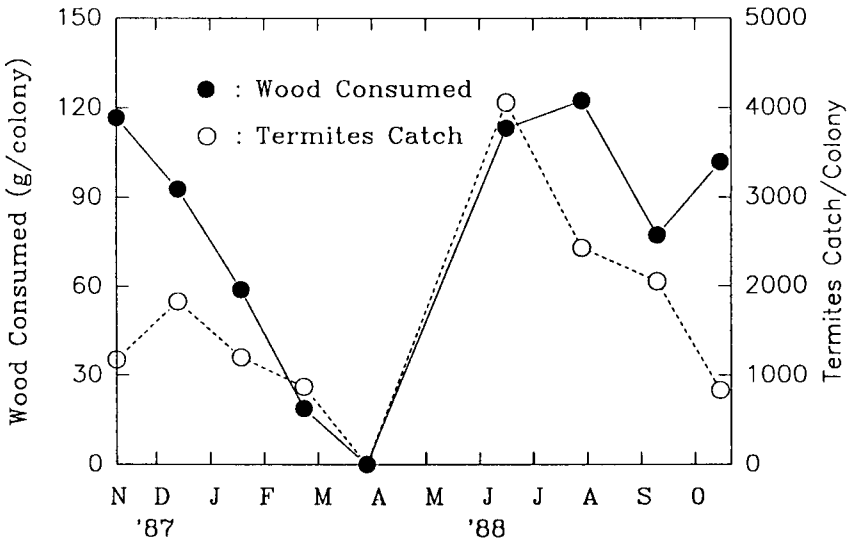


Fig. 2. Foraging activity expressed as the total wood consumed (solid circles with solid lines) and total number of termites collected (open circles dotted line) from a *C. formosanus* colony that received A-9248 treated baits between November 1987 and November 1988.

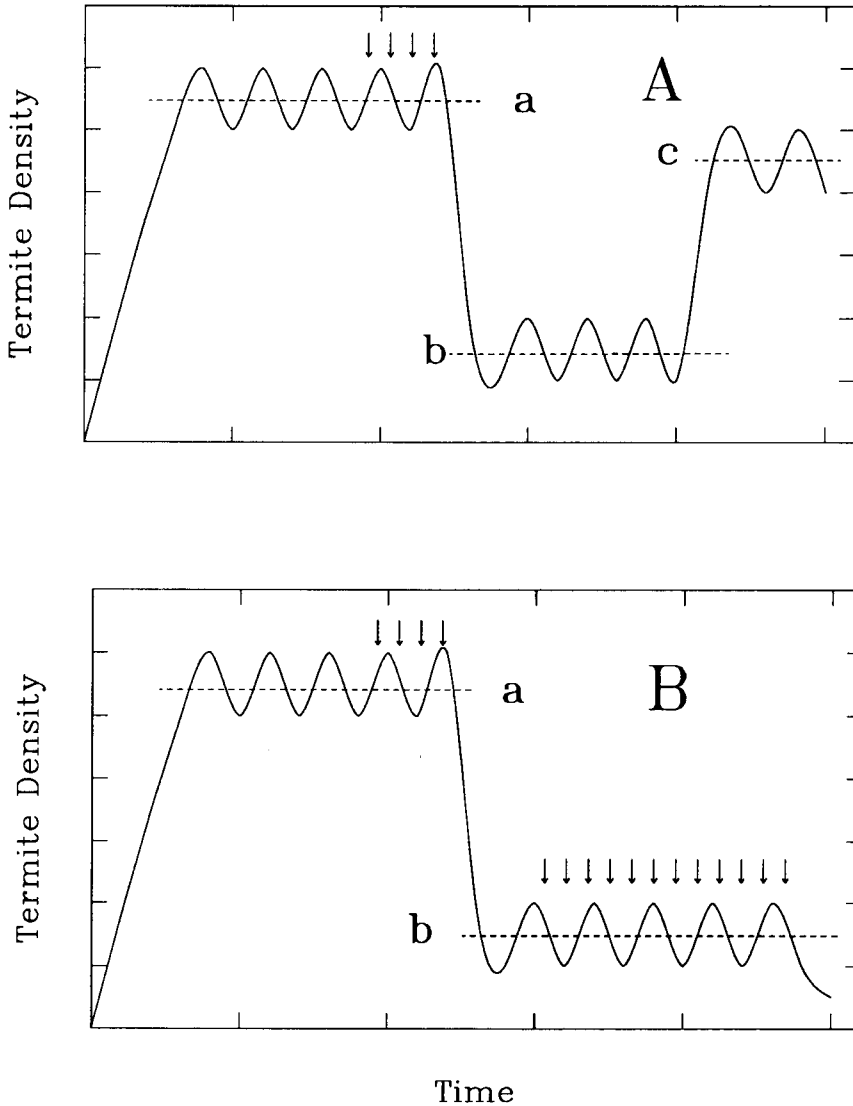


Fig. 3. Because of the apparent inability of soil termiticides to reduce subterranean termite populations, termite density in an area may eventually reach a damaging level (A, a). A bait toxicant application ( $\downarrow$ ) may reduce the subterranean termite populations below a tolerable level (A, b). The lack of continuous toxicant intake may allow the eventual rebound of the populations (A, c). To contain the subterranean termite population below a tolerable level (or economic threshold) a continuous baiting program ( $\downarrow$ ) may be needed (B, b).

There was a sudden surge of activity during the swarming season in May and June followed by a general decrease in foraging activity. This large fluctuation in foraging activity was characteristic of colonies that received toxic baits. It was not seen in colonies that received untreated wood blocks. Although there was a difference in the seasonal foraging activity between colonies that received toxic baits and those that received untreated wood, measurement of the foraging activity alone did not provide a clear indication of the effects of the bait toxicant against field populations of the Formosan subterranean termite.

**Foraging Population Estimates.** Because of the uncertainty of relying on the foraging activity for evaluating the effects of bait toxicants against field colonies of subterranean termites, we estimated the foraging populations of *C. formosanus* before and after the bait applications. When a multiple mark-release scheme was used (Su & Scheffrahn 1988) in conjunction with a weighted mean model (Begon 1979), the standard errors were generally less than 10% of the population estimates. With the information on the foraging populations we demonstrated that foraging populations of three *C. formosanus* field colonies were reduced 65 to 98% one year after bait application (Su *et al.*, unpublished data). In addition to foraging activity (number of baits attacked, extent of damage to baits, or number of termites collected from baits or ground stakes), foraging populations should be estimated before and after the bait application to adequately verify toxic effects on termites colonies.

It should be noted, however, when field populations are reduced by bait toxicants to such an extent that the foraging activity is no longer evident on the soil surface (Fig. 1D), neither foraging activity nor foraging populations can be measured to verify the result of field trials. A long term monitoring program, such as that done by Ostaff and Gray (1975), is probably the best method for confirming results. There is a need to develop new monitoring methods, such as acoustic or heat-sensing infrared devices, to better detect the presence of termite activity.

Because of the apparent inability of soil termiticides to reduce subterranean termite populations, termite density in an area may eventually reach a damaging level (Fig. 3A, a). The study with A-9248 (Su *et al.* unpublished data) suggested that a bait toxicant may reduce subterranean termite populations to a tolerable level

(Fig. 3A, b). After a period of bait application, the affected populations may no longer acquire toxicant from baits when the foraging activity is considerably diminished (Fig. 1D). The lack of continuous toxicant intake may allow the eventual rebound of the populations (Fig. 3A, c).

We are currently monitoring the population dynamics of *C. formosanus* colonies that previously received baits to examine the occurrence and mechanism of such a population recovery. To contain the subterranean termite population below a tolerable level (or economic threshold) a continuous baiting program may be needed (Fig. 3B, b). A continuous program may also be a good practice in areas with high subterranean termite population pressure where neighboring populations may move into the treatment zone.

#### ACKNOWLEDGEMENTS

R. H. Scheffrahn of the University of Florida, and M. I. Haverty of USDA/Forest Services reviewed the initial draft of this manuscript. Their comments greatly improved the quality of this paper. This article is Florida Agricultural Experiment Stations Journal Series No. R-01335.

#### REFERENCES

- Beard, R.L. 1974. Termite biology and bait-block method of control. Conn. Agric. Exp. Stn. Bull. 748, 19 p.
- Begon, M. 1979. Investigating animal abundance: capture-recapture for biologists. University Park Press, Baltimore, MD.
- Delaplane, K.S. & J.P. La Fage. 1989. Foraging tenacity of *Reticulitermes flavipes* and *Coptotermes formosanus* (Isoptera: Rhinotermitidae). Sociobiology 16:183-189.
- Esenther, G.R. & R.H. Beal. 1974. Attractant-mirex bait suppresses activity of *Reticulitermes* spp. J. Econ. Entomol. 67:85-88.
- Esenther, G.R. & R.H. Beal. 1978. Insecticidal baits on field plot perimeters suppress *Reticulitermes*. J. Econ. Entomol. 71:604-607.
- Esenther, G.R. & D.E. Gray. 1968. Subterranean termite studies in southern Ontario. Can. Entomol. 100:827-834.
- Gao, D., B. Zhu, B. Gan, S. He & S. Yuan. 1985. A new toxic bait for the control of forest-infesting termites. J. Nanjing Inst. For. 3:128-131 (in Chinese with English summary).

- Grace, J.K., A. Abdallay, & K.R. Farr. 1989. Eastern subterranean termite (Isoptera: Rhinotermitidae) foraging territories and populations in Toronto. *Can. Entomol.* 121:551-556.
- Hänel, H. 1983. Preliminary field tests on the use of *Metarhizium anisopliae* for the control of *Nasutitermes exitiosus* (Hill) (Isoptera: Termitidae). *Bull. Entomol. Res.* 73:305-313.
- Jones, S.C. 1988. Field evaluation of several bait toxicants for subterranean termite control: a preliminary report. 19th Ann. Meeting of the Int'l. Res. Group on Wood Preservation Doc. No. IRG/WP/1376, 11 pp.
- King, E.G., & W.T. Spink. 1969. Foraging galleries of the Formosan termite, *Coptotermes formosanus*, in Louisiana. *Ann. Entomol. Soc. Am.* 62:537-542.
- Li, T., K.H. He, D.X. Gao, & Y. Chao. 1976. A preliminary study on the foraging behavior of the termite, *Coptotermes formosanus* (Shiraki), by labeling with iodine-131. *Acta Entomol. Sinica.* 19:32-38 (In Chinese, with English summary).
- Ostaff, D. & D.E. Gray. 1975. Termite (Isoptera) suppression with toxic baits. *Can. Entomol.* 107:1321-1325.
- Paton, R. & L.R. Miller. 1980. Control of *Mastotermes darwiniensis* Froggatt (Isoptera: Mastotermitidae) with mirex baits. *Aust. For. Res.* 10: 249-258.
- Randall, M. & T.C. Doody. 1934. Poison dusts. I. Treatments with poisonous dusts. pp 463-476, In: Kofoid, C. A. (ed.) *Termite and termite control.* Univ. Calif. Press, Berkeley, CA.
- Spragg, W.T., & R. Paton. 1980. Tracing, trophallaxis and population measurement of colonies of subterranean termites (Isoptera) using a radioactive tracer. *Ann. Entomol. Soc. Am.* 73:708-714.
- Su, N.-Y. & R.H. Scheffrahn. 1986. A method to access, trap, and monitor field populations of the Formosan subterranean termite (Isoptera: Rhinotermitidae) in an urban environment. *Sociobiology* 12:299-304.
- Su, N.-Y. & R.H. Scheffrahn. 1988. Foraging population and territory of the Formosan subterranean termite (Isoptera: Rhinotermitidae) in an urban environment. *Sociobiology* 14:353-359.

