Termite Control: Decayed Wood Bait

by
Glenn R. Esenther[1]
and
Raymond H. Beal[2]

ABSTRACT

The literature on work with insecticidal termite baitwood is reviewed. It includes trials of treatment effectiveness under various field conditions and in conjunction with residential structures. The relation of bait treatment to preconstruction, construction, and post-construction stages of a building is discussed. Termite foraging behavior, behavioral factors in decayed wood, and antitermitic agents in baits are also discussed.

INTRODUCTION

Baits of preferred foods may be used to lure insects into contact with insecticide, and baiting is well suited to social insects because of their foraging, food exchange, and grooming habits. But, until recently, the bait approach had not been attempted for the control of termites. Indeed, the long-lasting effectiveness of termiticidal soil insecticide and chemical wood preservation treatments seemed adequate to protect wood used by man. Therefore, a need for new termite control methods was not apparent.

However, the onset of concern about the human and environmental hazards of persistent pesticides created doubts about the continued availability of long-lasting chemicals for termite control. Coinciding with such doubts was the report that subterranean termites were strongly attracted to wood infected with the brown-rot fungus *Gloeophyllum trabeum* (Pers. exFr.) Murr. (formerly *Lenzites trabea*) (Esenther et al. 1961). This stimulated development of termiticidal baits as a new termite control method. The present review will cover the experimental work to develop decayed-wood-insecticide treatments for the control of wood-destroying subterranean termites.

Wood use as monitoring bait in termite field research preceded work with termiticidal baits. For example, insecticides selected for barrier

[1]Forest Products Laboratory, Forest Service, U.S. Department of Agriculture, Madison, Wis.; maintained in cooperation with the University of Wisconsin.
[2]Forestry Sciences Laboratory, Forest Service, U.S. Department of Agriculture, Gulfport, Miss.

treatments have been based on their effectiveness in preventing termite attack on a susceptible wood stake or slab (Johnston et al. 1971). Termite-preferred wood also has been advocated to enhance the severity of exposure to termite attack in assessments of natural or preservative-treated wood and other materials (Gay et al. 1957; Behr and Smith 1976). Recently, rolls of toilet paper have also been used to monitor the foraging activity of termites (LaFage et al. 1973).

Initial efforts to establish the allurement potential of decayed wood bait in field trials were summarized by Esenther and Coppel (1964). A small block (1.9 cm cube) of *G. trabeum*-decayed wood lured termites to a reservoir of insecticide (dieldrin or chlordane in corrugated fiberboard) resulting in some mortality of forager termites. This demonstrated that a small piece of decayed wood could attract termites to an insecticide. The results, however, indicated that the foragers might have to pick up considerably more insecticide before a bait treatment would have an appreciable impact on a colony. The slow-acting stomach poison mirex, therefore, seemed a better choice for the bait insecticide because it would allow time for the foragers to transport the insecticide to the nest for distribution to other members of the colony.

MIREX BAIT TREATMENT TRIALS

A series of three field trials was initiated with decayed wood bait blocks and mirex to develop a practical treatment that would suppress *Reticulitermes* Holmgren populations in the ground. This work also included the development of monitoring techniques to evaluate treatment effectiveness. The approach to the field work was largely empirical because of the rudimentary state of knowledge on the social biology of subterranean termites, particularly their foraging behavior.

First Trial—The first field trial showed that a bait treatment could affect a termite population in the ground (Esenther and Gray 1968). This is provided the justification for developing a practical termite bait control method. The treatment unit was the 1.9 cm decayed wood cube planted 2 to 5 cm deep in the ground beside a wood marker stake (0.5×5×15 cm). Individual units, alternately with or without mirex, were placed at 1.5 m spacing in a grid, and resulted in the suppression of termite foraging activity on treated plots of ground. Termite damage to units was restricted almost entirely to the decayed block which indicated that the block by itself might be adequate both as a bait and as a reservoir of insecticide. The trial site was in southern Ontario. It was selected because the termites occurred in isolated pockets of infestation, thereby minimizing the complication of results from invasion of treated plots by a reservoir of termites in the vicinity.

Second Trial—This trial was designed as a severe test of the bait treatment. For this, Esenther and Beal (1974) selected a forested site on the Harrison Experimental Forest, Miss., where *Reticulitermes flavipes* (Kollar) and *R. virginicus* (Banks) were numerous and the decayed wood bait had to compete with a natural abundance of wood debris. They placed the mirex bait blocks (0.6 × 2.5 × 2.5 cm, avg. 32 mg insecticide) at 1.5 m spacing in a grid on plots of ground (7.5 × 15 m). A similar grid of termite-susceptible pine stakes (2.5 × 5 × 45 cm) was superimposed over the bait grid so that bait blocks were centered in each small square of the stake grid. Suppression of termite attacks on the stakes persisted for 3% years at which time the bait wood had been completely rotted by fungi.

Third Trial—This trial was initiated to determine whether simple treatment at the perimeter of plots of ground would suppress termite activity (Esenther and Beal 1978). The site was a tract of cleared land on the Harrison Experimental Forest where the *Reticulitermes* population had adjusted to the lesser nutrients as compared to wooded areas. Individual bait blocks contained 10 mg mirex and were planted at 1.5 m spacing. During the 3½ years that the site was monitored by observing attack on insecticidal bait blocks, the termite activity declined to virtual elimination.

Information from these studies indicated that bait treatment effectiveness must be considered in the context of the different stages in the construction of man-made structures. Before construction, a grid-type bait treatment can be applied to the ground surface. Therefore, suppression of the termite population by bait treatment should greatly alleviate the termite hazard on a construction site. This was confirmed by the major reduction of termite activity in trials 1 and 2.

During and immediately after construction, the termites at a building site would probably be disrupted by the construction activity. The colonies, in attempting to re-establish a network of foraging tunnels, would be particularly susceptible to the allurement of bait blocks. Baits planted at the perimeter of the building foundation would be in an ideal location to intercept the termites. Esenther and Beal (ongoing study) have been assessing this type of treatment using simulated buildings, consisting of a 6 m square concrete foundation wall and a wood roof. The construction site was the one where termites had been eliminated in the third field trial. Therefore, logs containing large termite colonies were planted on the site as a resident population. Preliminary results indicate that the bait treatment was effective in suppressing the large colonies.

Some time after a building is constructed, the termite hazard on a residential property is difficult to assess: there is no simple way to locate nests or to estimate the termite population in the ground. Ostaff and Gray (1975) evaluated perimeter type mirex bait treatments on residential properties in Toronto, Ontario. Except for two cases where the termites appeared to invade the buildings after treatment, their treatments sup-

pressed the termite activity on the properties. They thought that the two failures may have resulted from colonies nesting under the buildings which were diverted up into the buildings by slight contact with insecticidal bait. Such diversion of foraging activity away from baits was noted by Esenther and Beal (1978) in the third field trial. This potential for treatment failure indicates that knowledge of both termite foraging habits and building construction is needed to place baits at critical locations to ensure treatment effectiveness.

Beard (1974) described the use of mirex baits to treat termite-infested buildings. He placed noninsecticidal bait blocks at points accessible to the termites. When termites attacked these blocks, he replaced them with mirex-treated blocks. Generally this resulted in the suppression of termite activity and, presumably also, in the elimination of a colony. In one case, however, it was necessary to repeat the treatment the following year. Our 1978 results with such spot treatments were similar to his, but we noted that the apparent elimination of a colony in a building could not be confirmed directly. It appears, therefore, that remedial treatments will require post-treatment surveillance by a termite control specialist.

The work to date shows that bait treatments can be effective; however, the failures of treatments on residential properties (Beard 1974; Ostaff and Gray 1975) illustrate the need for improvements. Perhaps only greater attention to placement of bait at critical locations in or under buildings will provide consistent reliability in treatment effectiveness.

TERMITE FORAGING BEHAVIOR

The effectiveness of termite bait control treatments depends on bait contact by the termites during foraging, but there is surprisingly little precise information on termite foraging. Elsewhere in this symposium series, McMahan reviewed temporal polyethism in termites. She noted that large older worker stadia were associated with foraging by some species of termites. There is no information on whether such age polyethism occurs in *Reticulitermes*, the most economically important termite genus in North America. Esenther (1969) noted that fluctuations in foraging by *R. flavipes* were associated primarily with fluctuations in the caste composition in a colony. Secondarily, temperature and moisture conditions modified that fluctuation. However, precise studies of foraging, such as those of LaFage et al. (1973) and Haverty et al. (1975) on desert subterranean termites, have not been done with *Reticulitermes.*

BEHAVIORAL FACTORS IN DECAYED WOOD

Since the original observation on the attractancy of G. trabeum-decayed wood to termites, considerable progress has been made in clarifying the

nature of the attractant and other types of behavioral factors in decayed wood (Becker 1975). Features pertinent to decayed wood baits will be repeated briefly and updated herein.

The attractant factor is thought to be (Z,Z,E)-3,6,8-dodecatriene-l-ol, the trail pheromone of *R. virginicus* (Matsumura et al. 1968,1969; Tai et al. 1969). This compound had trail-following effects on several *Reticulitermes* species and *Coptotermes formosanus* Shiraki (Howard et al. 1976). Its presence in wood is due to the fungus. However, its production varies depending on both the particular fungus culture and type substrates (Matsumura et al. 1972, 1976; Amburgey and Smythe 1977a). Except for Lund's (1970) comment that vanillin lured termites, neither the dodecatnene nor any other extract or chemical attractive in bioassays has been reported effective for luring termites in natural settings.

Several types of termite behavioral responses have been noted with brown-rot fungi. Esenther and Coppel (1964) suggested that *G. trabeum*-decayed wood contains a feeding stimulant. Becker and Lenz (1972,1976) demonstrated feeding and gallery building stimulants in various decayed woods, as well as an influence on caste development. Amburgey and Smythe (1977b, 1977c) added various arrestant, chewing, and gustatory effects to the list of termite responses to brown-rotted woods. They also noted that the seeming importance of such factors in wood varied with the bioassay used.

The biological significance of the various behaviorally active factors in decayed wood is obscure. The job of isolating and identifying those components remains. Differences in order of preference in different multiple choice bioassays (Amburgey and Smythe 1977b, 1977c) indicate that information from field testing is required before laboratory results can be interpreted correctly. Unfortunately, at the moment, only field information on bait wood infected with the G. trabeum culture, Mad-617, is available.

Termite species in the families *Hodotermitidae, Kalotermitidae, Rhinotermitidae,* and *Termitidae* have been exposed to brown-rot fungi in both force- and choice-type bioassays (Esenther and Coppel 1964; Allen et al. 1964; Smythe et al. 1967; Becker and Lenz 1972, 1976; Matsuo and Nishimoto 1974). Here, too, the specter of artifactual effects in the bioassays may cloud interpretation of results. Nevertheless, it appears that the best fungus for a decayed wood bait will differ depending on the termite species and perhaps also geographical location.

ANTITERMITIC AGENTS IN BAITS

Mirex was the insecticide of choice in past efforts to develop termite bait control methodology. Discontinuation of the production of mirex requires the selection of other antitermitic agents for continuing efforts to get bait treatments into use.

Guidelines for selecting candidate antitermitic agents for baits must include considerations of their availability, environmental acceptability, and physical and chemical properties. Biologically, any repellency or distastefulness might eliminate a candidate material.

Although the guidelines would eliminate many materials, a considerable latitude on types of candidate materials exists. Esenther and Beal (1978) suggested that a slow acting stomach poison might be best for the termite bait treatments, because it would permit a greater number of termites to ingest the insecticide before the adverse effects caused a cessation of feeding. Synthetic insect growth regulator chemicals might be particularly promising agents in baits because of their specificity of effect on arthropods. Of these, the juvenile hormone analogs have induced excessive soldier development in termites (Lenz 1976); this might result in a serious imbalance in the caste composition of a termite colony. A unique approach would be the use of an agent to eliminate essential symbionts in the termite gut; antibiotics and components of termite-resistant woods eliminated protozoa from the termite gut (Mauldin 1978; Carter 1975). A microorganism might be used as a biological control agent in baits; Becker's (1975) review on microorganisms detrimental to termites may indicate organisms useful in this respect.

Uncertainty about the continued availability of currently used termiticides indicates the urgency of finding acceptable insecticides for conventional treatments and of developing termite bait control to a use status. Many of the potential antitermitic agents will require an extensive research effort to determine their effectiveness. The immediate need in the bait approach is to find an insecticide that will be at least similar in effectiveness to mirex.

Before bait control treatments can achieve general use, a feasible method to produce bait commercially is needed. Several hundred thousand mirex bait blocks have been produced at the Forest Products Laboratory, USDA Forest Service, Madison, Wis. 53705 (method available upon request). However, further development is needed to mass produce a marketable product.

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