A REVIEW OF THE BAIT-TOXICANT METHOD OF TERMITE CONTROL

IN SEARCH OF THE HOLY GRAIL

by

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The cyclodiene termiticides, aldrin, chlordane, dieldrin, and heptachlor, have been used successfully as soil poisons to prevent and control subterranean termites for more than 25 years. Their success can be attributed to their well-recognized efficacy (Beal et al. 1983), relatively low cost, and ease of application.

Recently, however, environmental groups and others fearing adverse effects on human health from exposure to long-lasting residues, have called for much more stringent controls on their use in structures and in some instances, cancellation of registrations.

In addition, no soil poison can be effective for controlling aerial nests of the Formosan subterranean termite, Coptotermes formosanus Shiraki. This extremely damaging subterranean termite is found in several southern states and in Hawaii where it often constructs large nests which have no ground contact.

Recognizing these concerns, scientists have been working to develop new control strategies for subterranean termites. Research has focused on a search for cyclodiene replacements and for new methods of delivering toxicants to the termite nest.

An organophosphate insecticide, chorpyrifos (Dursban ,DOW USA), has been registered in the USA for soil application against Reticulitermes spp., C. formosanus, Heterotermes aureus and Zootermopsis spp. It is being used to a limited extent especially where pest-control operators fear possible contamination of embedded heating ducts in slabs.

Many additional insecticides have or are being tested for use against termites. Among these are some well-known organophosphates and carbamates as well as totally new classes of compounds developed specifically for termite control. Some are being investigated for use as remedial treatments while others may have preventative value as well.

Examples of this research include the work of Prestwich et al.(1981, 1983) on the fluorolipids, Su et al. (1982) on Amdro and Carter (1975) on natural wood extractives. La Fage et al. (1983) evaluated the effects of a fumigant, sulfuryl fluoride, to control aerial nests of the Formosan termite in Louisiana. Several products have been registered for above-ground spot treatment of dry-wood termites and some of these may also have limited applications against subterranean termites.

Biological control agents such as pathogenic fungi and nematodes have been studied (Lai 1977; Lai et al. 1982) and the latter are being used commercially by some pest-control operators where the risks of using soil poisons are too great. Wood preservation with highly repellent compounds has been investigated also. Chemicals which act against the wood-digesting protozoans and bacteria in the termite's digestive system (Mauldin and Rich 1980) represent a novel control strategy. Japanese workers are working with products which prevent nitrogen fixation in the termite gut (Takahashi, personal communication).

The insect growth regulator, methoprene, which is currently being used by PCO's against pharaoh's ants, mosquitoes, and fleas, has been studied for termite control and the research is promising (Howard 1984, Jones personal communication).

With regard to toxicant delivery, the method cited most often as possible replacement for soil poisoning, is the bait-toxicant system. Many of the new toxicants being developed are compatible with this delivery technology although some are not, e.g., the repellent wood preservatives.

The bait-toxicant concept is based on important behavioral characteristics of the termite colony. Termites are eusocial insects that live in social units which are long lived with several generations coexisting simultaneously. The colony consists of different classes of individuals organized into work units called castes that are distinguished by specialization in behaviour and anatomy. Reproductives produce young, soldiers defend the colony, and larvae ("workers") care for young and forage for food. Foragers travel considerable distances from the nest to collect cellulosic materials. They are responsible for providing food for the dependent castes (soldiers, reproductives, and young larvae) which are incapable of feeding themselves. When a forager returns to the nest with a fresh supply of food, it shares it with the dependent castes. The bait-toxicant control strategy is based upon the theory that a slow-acting nonrepellent toxicant, combined with the food gathered by foragers, will be transferred to the dependent members of the termite colony before its toxic actions are exerted upon the foragers.

Although the food transfer rate is dependent upon the size and composition of the colony, studies have demonstrated that distribution to nestmates may be completed within 24-96 hours (Alibert 1959, McMahan 1966). A toxicant with a delayed action of ca. 96 hours would be ideal for use with baits.

Esenther and Coppel (1964) were the first to suggest the use of toxic baits for subterranean termite control. Esenther et al. (1961) had reported earlier that Reticulitermes spp. were

strongly "attracted" to wood which had been infected by the brown-rot fungus, Gloeophyllum trabeum (Pers. ex Fr.) Murr. Field studies with corrugated paper/decayed-wood units confirmed that fungus-infected baits were preferable to sound wood.

The significance of an "attractive" bait is clear; if the bait-toxicant system is to be effective, termites must find the baits and consume quantities of the toxicant sufficient to deliver a lethal dose to the colony. Any characteristic that causes a bait to be more easily located or leads to enhanced feeding will improve the chances for the technique to work.

When decayed baits were used with dieldrin or chlordane (Esenther and Coppel 1964), very little termite mortality was noted. These toxicants were apparently too repellent or fast-acting to be effective.

Esenther and Gray (1968) reported work on bait toxicants in Toronto. Marker stakes and decayed bait blocks impregnated with the slow-acting nonrepellent stomach poison, mirex, were set in fields and around structures. Termite attacks on marker stakes in treated plots decreased during the 12-month study while they increased on check plots. Decayed baits were clearly preferred over sound wood and the authors concluded that the toxic baits effectively suppressed foraging activity and termite damage.

Esenther and Beal (1974) used the bait-toxicant method to suppress Reticulitermes spp. in Mississippi where the termite hazard was greater than in Canada. Comparisons of bait-block efficacy were made among plots with decayed blocks only, mirex impregnated in sound blocks and mirex-impregnated decayed blocks. In most test plots, attacked blocks were replaced at each check but in three, the effects of a single initial application of toxic baits was assessed after three years.

Here, as in Canada, the mirex baits were effective for suppressing termite attacks on reference stakes. The single application of bait blocks maintained its effectiveness for more than three years.

The small amount of pesticide required to suppress termites was significant; on one plot (112.5 square meters) only 2.1 g (equivalent to only 0.16 lb/acre) of mirex was necessary to suppress activity.

Beard (1974) described the results of a series of laboratory and field studies using G. trabeum-decayed mirex bait blocks to control R. flavipes in Connecticut. He used a prebaiting technique in which untreated decayed baits were placed near active foraging sites. After these baits were discovered and substantial numbers of termites recruited, the untreated blocks were replaced with mirex-treated baits. The results were promising but inconclusive. In most cases activity was suppressed or eliminated but there were failures evidenced by flights which were staged during the following spring.

Beard (1974) disputed Esenther's claim that G. trabeum-decayed blocks were attractive, i.e., capable of guiding termites across a chemical gradient, claiming rather that foraging was random. Also of note was his laboratory experiment on the rate of toxicant transfer among colony mates. Test groups were killed when as few as 10% of their members had fed on mirex source blocks.

Ostaff and Gray (1975) reported the results of a second study in Ontario with mirex blocks used to control subterranean termites on eight residential properties. An average of 50 impregnated blocks each containing 10 mg of mirex were buried around buildings on properties where termite activity had been noted previously. Termite activity was suppressed in seven of the eight properties after three years but in one case, professional termite control was required to eradicate termites attacking a wooden porch and kitchen area. The authors speculated that failure might have been due to the presence of a colony located directly under the building. Remedial control, as practiced by Beard (1974), was not attempted.

Esenther and Beal (1978) provided additional data on the use of bait-toxicants in Mississippi with a study on the effects of perimeter treatments on unobstructed field plots. The absence of structures on the plots made it possible to monitor termite foraging activity inside the treatment perimeters. Semiannual inspections revealed results similar to those of earlier studies; termite activity was suppressed effectively using the mirex baits during the 3 1/2-year study. Monitoring blocks placed on untreated buffer zones were also protected. At the same time, however, some incipient colonies were noted on the plots during the final stages of the study.

Mirex baits were used against the large primitive Australian termite, Mastotermes darwiniensis Froggott by Paton and Miller (1980). Their technique was similar to that of Esenther and Beal (1974) and Su et al. (1982) with the exception that radioisotopes were used to mark the limits of colony foraging distribution (Spragg and Paton 1980) prior to treatment with mirex baits. The speed and thoroughness of termite suppression was impressive. In one field test, foraging activity of a colony occupying 46 trees and logs across a distance of ca. 80 meters, was completely eliminated only one week after the mirex baits were installed. Many pockets of dead and decaying termites were found but no live radioactive foragers could be recovered.

Su et al. 1982 reported preliminary findings from field tests in which Amdro baits were used to control the Formosan subterranean termite in Hawaii. Their results were inconclusive. Amdro concentrations (6400 ppm) which were not repellent in the laboratory were accepted initially, then rejected in the field. Lower concentrations (180 ppm) were accepted by field foragers but had no apparent effect on colony vigor. Two field colonies were treated with very high levels of Amdro (15,000 ppm); one showed reduced foraging activity while the other was not affected. Even though the 15,000 ppm dosage was more repellent

than the 6,400 ppm concentration, it appeared that sufficient toxicant was ingested to partially suppress one colony.

More field and laboratory work is needed on this compound and others including the growth regulators, fluorolipids and antibiotics to determine the future of the bait-toxicant method of delivery. It also should be possible to use new methods of formulating insecticides to reduce repellency and delay toxic actions. There has been considerable interest in slow-release formulation chemistry in recent years especially with insecticides used for cockroach control. It would seem logical that the fruits of that research could be applied to the termite toxicant problem.

Additional studies similar to those of Paton and Miller (1980) are needed to determine colony size, foraging patterns and rate of food transfer for North American termites. More information is needed on the nature of termite-fungus interactions. Also, to date, no one has developed an acceptable field bioassay to evaluate the efficacy of baiting experiments. One is always left with questions concerning effects on the colony and extent of suppression. One possibility might be to test bait-toxicants against entire colonies in the laboratory. While this may be difficult with Reticulitermes spp., it is possible for the Formosan termite.

Bait-Toxicant control is a very attractive concept. The quantities of pesticides necessary to eradicate large termite colonies are extremely small and their effects would be directed toward a single target pest. Although the method has shown considerable promise, many question remain. Much more research will be needed before the final verdict on commercialization can be predicted.

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