MANAGING SUBTERRANEAN TERMITE POPULATIONS

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Abstract—Soil termiticide treatments provide a barrier to exclude soil-borne termites from structures. The vast populations of subterranean termites are generally unaffected by the termiticide application. In the future, monitoring, exclusion (physical or chemical barriers), and population suppression devices (bait-toxicant) will play the major role for the management of subterranean termites.

INTRODUCTION

Termites in the United States are categorized into three general groups: subterranean termites (Rhinotermitidae), drywood termites and dampwood termites (Kalotermitidae). Of the approximately $1.5 billion spent annually for termite control in the U. S., subterranean termites account for an 80% share. Triple mark-release programs using dye markers such as Sudan Red 7B and Nile Blue A revealed that a single subterranean termite colony may contain millions of foragers and may forage a distance of up to 100 m (Su & Scheffrahn, 1988a; Grace, 1990; Jones, 1990). These data indicated the presence of a large subterranean termite colony beneath an infested structure (Su, 1991) (Fig. 1A). Conventional soil termiticide applications apparently do not reduce population size of the vast subterranean colony (Su & Scheffrahn, 1988a). There are two potential approaches to the management of these subterranean termite populations near structures; 1) exclusion, and 2) population suppression.

Exclusion Approach

a) *Chemical barrier.* For the last four decades, the pest control industry has depended heavily on soil termiticides for subterranean termite control. The objectives of soil termiticide application are to create a chemical barrier that excludes soil borne termites from structures (Fig. 1B). If applied properly, a pre-construction treatment could provide a continuous termiticide barrier. A post-construction treatment, however, may leave gaps of untreated soil beneath foundation slabs because liquid movement in sub-slab soil is unpredictable. As of February 1993, one organophosphate (chlorpyrifos) and four pyrethroids (permethrin, cypermethrin, fenvalerate, and bifenthrin) are

Table 1. Termiticides available for subterranean termite control in the United States as of February 1993.

Product	Active Ingredient	Chemical Class	Concentration (%)	Manufacturer
Dursban® TC	chlorpyrifos	organophosphate	1	DowElanco
Equity®	chlorpyrifos	organophosphate	0.75, 1	DowElanco
Tenure®	chlorpyrifos	organophosphate	0.75, 1	DowElanco
Dragnet® FT	permethrin	pyrethroid	0.5, 1, 2	FMC
Prevail® FT	cypermethrin	pyrethroid	0.3, 0.6, 12	FMC
Biflex® FT	bifenthrin	pyrethroid	0.06, 0.12	FMC
Demon® TC	cypermethrin	pyrethroid	0.25, 0.5	Zeneca
Torpedo®	permethrin	pyrethroid	0.5, 1	Zeneca
Tribute®	fenvalerate	pyrethroid	0.5, 1	Roussel UCLAF

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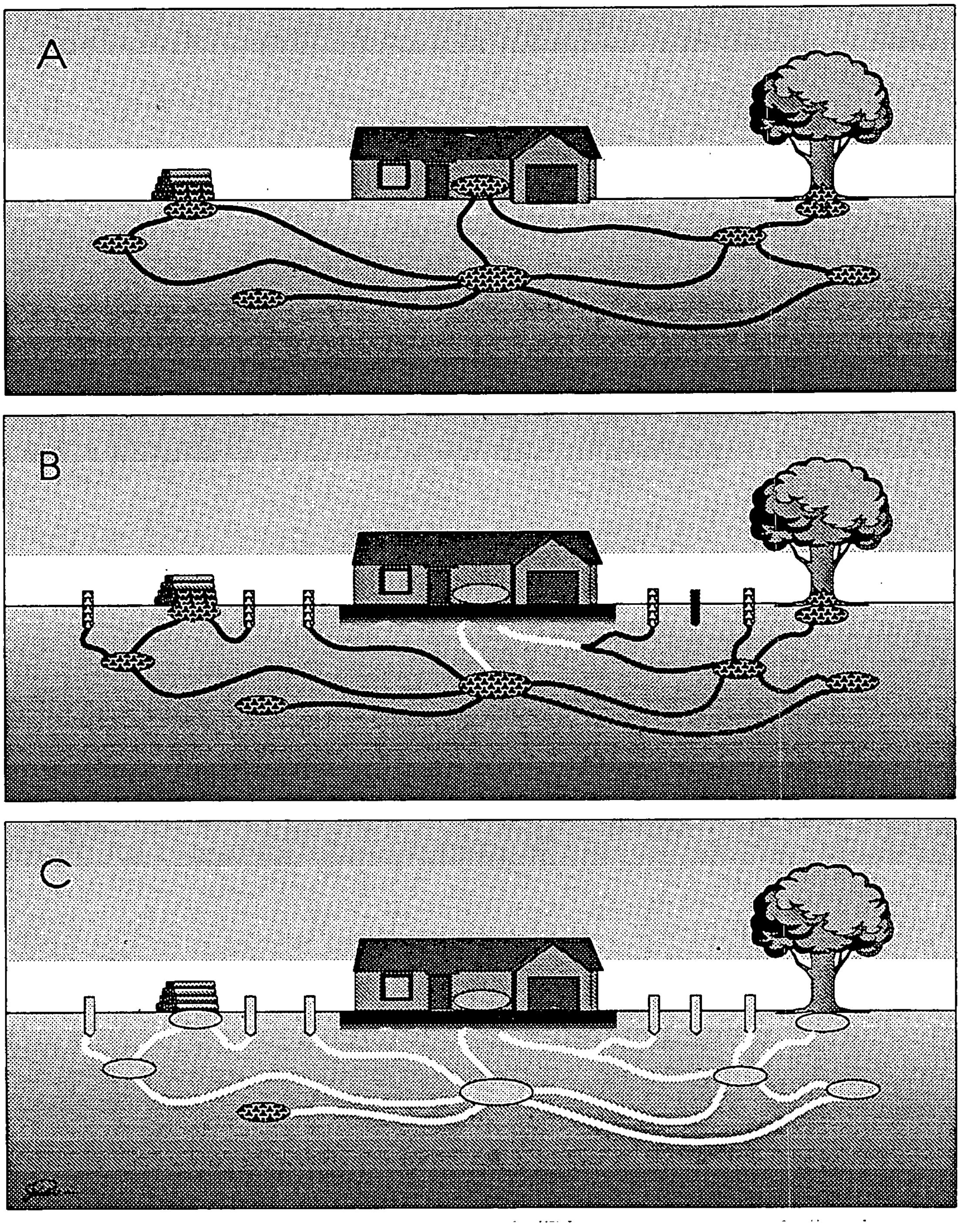

Fig. 1. A single colony of subterranean termite may contain millions of termites and cover a foraging distance of up to 100 m (A). The conventional soil treatment beneath the structure provides barriers to exclude soil-borne termites from structures, but do not reduce termite populations (B). A monitoring/baiting program may be used to reduce subterranean termite populations near structures (C).

marketed as termiticides under nine brand names for the pest control industry (Table 1). Aside from the USDA-Forest Service Gulfport laboratory that has been testing termiticide efficacy and longevity for registration in the United States, several research institutes (e.g., University of Hawaii, North Carolina State University, Texas A&M University, Mississippi State University, and University of Florida) are field testing termiticides at each location. Results from these independent research institutes prompted the voluntary withdrawal of one product (Pryfon, isophenfos, Miles Inc.) from the market in 1992.

b) *Physical barrier.* Ebeling & Pence (1957) first suggested a non-chemical barrier alternative when they discovered that barriers consisting of sand particles ranging in size from 10-16 mesh (equivalent to particles of 1.2-1.7 mm in diameter) were not penetrated by the western subterranean termite, *Reticulitermes hesperus* Banks, in a laboratory test. Their observation indicated that the particles were too large for termites to displace with their mandibles, yet were small enough so termites could not maneuver between them. Because of the availability of inexpensive and effective soil termiticides, their discovery had been overlooked until the mid '80s when Tamashiro *et al.* (1987) confirmed that these results could be applied to the Formosan subterranean termite, *Coptotermes formosanus* Shiraki. Furthermore Smith and Rust (1990) found that *R. hesperus* did not penetrate barriers consisting of particles of 8-20 mesh (0.85-2.36 mm diam.).

A laboratory study by Su *et al.* (1991a) indicated that soil barriers composed of particles 1.7-2.4 mm in diameter were not penetrated by *C. formosanus,* and that a wider size range of particles (1.00-2.36 mm) excluded penetration by the eastern subterranean termite, *Reticulitermes flavipes* (Kollar). Although *C. formosanus* coexists with *Reticulitermes* spp. in some areas of Florida (Scheffrahn *et al.*, 1988), the laboratory study showed that barriers composed of mixed particle sizes (1.18-2.80 mm) effectively prevented penetration by both *C. formosanus* and *R. flavipes.* When the laboratory prepared sized particle barriers were exposed to field populations of subterranean termites, effective ranges were smaller than those reported from the laboratory study. In areas where both *C. formosanus* and *Reticulitermes* spp. occur, the two single-size particle barriers (2.00-2.36 mm and 2.36-2.80 mm) appeared to be the most effective exclusion devices against field populations of these subterranean termites (Su & Scheffrahn, 1992).

Currently, field studies are being conducted by the USDA-Forest Service Gulfport Laboratory, University of California at Berkeley, and University of Hawaii to collect data for the sized particle barrier method. Although studies have shown that this physical barrier technique may be a useful exclusion device, there is no standardized protocol for its proper installation. Some venders offer installation of sized particle barriers in existing structures, but skepticism remains over the effectiveness of such post-construction applications. Because of the differences among structural construction types, there are obvious difficulties in determining a proper installation protocol that is applicable to all construction practices. Furthermore, there is no regulatory mechanism to oversee the quality of sized particle products and their proper installation. These mechanisms need to be instituted before the establishment of a commercial practice of this physical barrier technique. Another physical exclusion device recently developed is a stainless-steel mesh which is installed between a structure and the soil. Again, the physical barrier can be properly installed only before the erection of the structure foundation. This pre-construction procedure is currently available only in Australia (Verkerk, 1990).

Population Suppression

Bait-toxicant application

Unlike the barrier methods, the objectives of bait-toxicant applications are to suppress the populations of subterranean termites in soil (Fig 1C). This is accomplished by providing a means for individual termites to acquire a lethal dose of slow- acting toxicant at an accessible foraging site. The toxicant has to be nonrepellent to termites, or at least be masked by other agents to prevent feeding deterrence or avoidance behavior by foragers. Baits containing dechlorane (Mirex) have been applied to field colonies of subterranean termites (Esenther & Beal 1974, 1978; Paton & Miller 1980, Gao *et al.*, 1985). Except for the study by Paton & Miller (1980), who used radioisotopes to monitor activities of field colonies before and after bait application, results of most of the previous

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field studies were inconclusive due to the lack of information on the target populations. Several slow-acting toxicants (Su *et al.*, 1987; Su & Scheffrahn 1988b, 1988c) and insect growth regulators (IGRs) (Jones 1984; Su *et al.*, 1985; Haverty *et al.*, 1989; Su and Scheffrahn 1989) were identified as candidate active ingredients (AIs) in laboratory studies. Jones (1988), who placed wooden stakes impregnated with fenoxycarb in the field, observed an increase of presoldiers and soldiers in colonies of *Reticulitermes* species and a subsequent decline in their foraging activities. A field study with baits treated with a slow-acting toxicant (A-9248) demonstrated that foraging populations of three *C. formosanus* colonies were reduced 65-98% (Su *et al.*, 1991b). More recently, bait matrix incorporating a chitin synthesis inhibitor (hexaflumuron) reduced field populations of *C. formosanus* and *R. flavipes* (0.2-2.8 million foragers per colony) by 90-100%. These studies demonstrated that if applied properly, only a small amount of bait-toxicant is needed to suppress field populations of subterranean termites.

Managing The Subterranean Termite Populations

Integrated pest management (IPM), devised as the rational solution for the long-term reliance on a handful of organic pesticides used in crop protection, is defined as the "intelligent selection and use of pest control options in an ecologically, and sociologically compatible manner" (Rabb, 1972). All available management techniques are employed in IPM programs to suppress pest populations to economically acceptable levels (Sawyer & Casagrande, 1983).

For the last four decades, enormous effort and resources have been dedicated to develop IPM programs for various agricultural pests (Metcalf & Luckmann, 1978), while soil termiticides and fumigants remain the main techniques for termite control. IPM programs for structural insect pests are virtually non-existent. Habitats for urban pests are generally more heterogeneous than those of agricultural insects, yet fewer control techniques are available for urban pests. For example, structural environments which harbor termite infestations differ greatly while soil treatments, fumigation, and spot treatments are the only techniques available for termite control.

Monitoring the populations of subterranean termites is an essential step for a successful IPM program. Various methods for detecting active infestations of termites in structures have been available to the pest control industry. These include acoustic emission detectors, termite detection dogs, moisture meters and more recently, a device that reportedly detects methane, a termite waste product. None of these commercially available techniques, however, have been scientifically tested for their efficacy. Research projects have been recently initiated to examine the feasibility of acoustic emission detectors (Lewis & Lemaster, 1991). Field traps using toilet rolls (La Fage *et al.*, 1973), wooden blocks (Tamashiro et al., 1973; Su and Scheffrahn, 1986), and corrugated cardboard (Grace et al. 1989) have been used for studying foraging populations and territories of subterranean termites. A simpler method however, has to be developed for the pest control industry to better survey subterranean termite populations. Monitoring, exclusion, and population suppression devices will be the three major tools for the management of subterranean termites in the future.

Pre-construction procedure. Prior to the construction of a building, monitoring devices may be employed to detect the presence of subterranean termites. If termites are present, baiting procedures may be used to suppress these populations. Because the most effective exclusion device, a continuous horizontal barrier, may be installed only before the building foundation is erected, conventional soil termiticide treatments should remain a viable tool for pest control industry. Physical barriers (sized particle or stainless steel mesh) can be used as alternative pre-construction barriers. After the barrier treatment, the monitoring/baiting procedure may be offered as an on-going program to prevent future infestations by remaining populations of the baited colony, invading colonies or a new colony initiated by alates.

Post-construction procedure. Most home owners would not tolerate termite activity on their properties and would demand immediate action. When a house is already infested by termites, termiticide treatments need to be employed to eliminate the structural infestation (spot treatment) and to provide chemical barriers surrounding the structures (trenching, etc.). After these remedial treatments are made, monitoring devices may be installed to detect activity of soil borne termites, followed by baiting procedures when termites are detected. After population suppression, the monitoring/baiting program may be continued for long term protection of the structures from subterranean termites.

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