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SUBTERRANEAN-TERMITE-BAITING SYSTEMS

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For the past 30 years, or so, subterranean termite management in Australia has relied mainly on chemically-treated soil barriers using the highly persistent cyclodiene (organochlorine) insecticides (aldrin, dieldrin, chlordane and heptachlor). These chemicals were de-registered and withdrawn from use from 30 June 1995. Alternative strategies for subterranean termite management in buildings and structures have been developing, well before this withdrawal. One of these strategies, which uses so called "termite-baiting systems", is introduced in this publication. The concept of termite baiting, the aggregation of termites in baiting stations and the application of toxicants are discussed, with respect to feeding habits and behaviour of some termites that damage timber-in-service in Australia.

Economic importance

Australia has a diverse termite fauna and is represented by the families Mastotermitidae, Termopsidae, Kalotermitidae, Rhinotermitidae and Termitidae. The five families include about 30 genera with 258 described, and at least 90 undescribed species. Termites can be grouped into three categories; dampwood, drywood and subterranean.

Most of the species of termites that damage timber-in-service in Australia are subterranean termites. *Mastotermes darwiniensis* and *Coptotermes* spp. are the most destructive. *Coptotermes acinaciformis* (Figure 1) is responsible for more economic loss than all the other Australian species combined. This is due to its extensive range, the severity of its attack, and its ability to survive in built-up areas such as cities and large towns. Some species of *Schedorhinotermes* and *Nasutitermes* are also of economic importance. *Nasutitermes exitiosus* is particularly wide-spread in the cool temperate regions of the southern mainland states.

The annual cost of termite damage to buildings in Australia is not known, but estimates exceed $100 million. The cost of imported chemicals used in termite management may exceed $20 million annually. Whatever the real figures, termites can cause significant damage with devastating financial and social implications for building owners.

Figure 1. *Coptotermes acinaciformis* soldier.

Feeding habits and behaviour

Cellulose is the basic food requirement of all termites, and all types of plant material can be damaged. Most termite species eat grass and other surface vegetation and have an important role in maintaining soil fertility and aeration. Other termite species infest timber, particularly that which is in an early state of decay caused by wood-rotting fungi.

Several timber species possess natural properties which make the heartwood resistant to termite damage. Most termite species which infest timber can damage the sapwood of softwoods, for example hoop, slash and radiata pines. However, all wood-feeding *Nasutitermes* spp. damage hardwoods only.

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Subterranean termites forage for food by means of covered runways (“galleries”) which extend from the central nest to food sources above (Figure 2) or below ground. The gallery system of a single colony may exploit food sources over as much as one hectare, with individual galleries extending up to 50m in length. In the case of the giant northern termite *M. darwiniensis*, individual galleries may extend as far as 200m. Usually only workers and soldiers visit the feeding sites, but nymphs are sometimes present. Other members of the colony generally remain in the nest. Foraging activity is seasonal, and may slow down or even stop during winter. Most termites need a plentiful supply of water, part of which they obtain from damp soil. Foraging termites aggregate in warm, moist areas containing susceptible timber, although exploratory foraging is thought to be at random.

Termites have a thin skin (“integument”) and desiccate readily. Apart from some grass-eating species which forage in the open, all termites remain within a closed system of galleries, devoid of light. The only exceptions are during a swarming flight, or when repair or new construction is occurring. The advantages to the termites of this closed system are twofold. They are protected from natural enemies such as ants, and they gain a measure of protection from temperature and humidity extremes.

Termites share food, feed their young, and regularly groom one another and often cannibalise their dead. These important behavioural aspects have been recognised and exploited for many years through the use of small quantities of arsenic trioxide dust puffed into active termite galleries as a remedial treatment. The dust adheres to the bodies of the passing termites and is distributed into the colony. Death of the termite queen and eventually the colony can follow. Similarly, termites can consume a cellulose-based bait containing a toxicant, and ultimately cause the death of the colony.

Figure 2. Galleries of *Nasutitermes walkeri*.

Concept of termite baiting

A bait is a food, or some substance, used to attract, entice or lure a specific organism to a desired location. Therefore, baiting for subterranean termites is not strictly “baiting”, because the termites are not strictly “attracted, enticed or lured” to most baits. The deficiency may be with the baits used and not with the term. However, the principle of baiting techniques is to have a susceptible substance in an aggregation device (“bait station”) on which the termites aggregate and continue to feed once they have found the bait station. Bait stations can be placed in in-ground and above-ground situations. Placement of baits in areas conducive to termite activity (“directed placement”) enhances the chances of contact with foraging termites. A bait toxicant in timber or a cellulose matrix can be placed in the station or the colony may be indirectly destroyed by dusting aggregated termites. Some bait toxicants eliminate the colony while others suppress the colony. However, both methods reduce potential to cause further damage to timbers.

Termite baiting is most beneficial when used as part of an integrated-pest-management strategy. Colony elimination or suppression should be followed by hazard reduction and regular inspection. Monitoring should continue because only a small amount of toxin is used and does not prevent foraging by other termite colonies that may be present in the foraging range of a timber structure.

Termite aggregation

Several techniques are developing to aggregate termites in stations prior to treatment in in-ground and above-ground situations. Care should be taken when inspecting stations because termites, especially *Coptotermes frenchi*, tend to retreat from and to avoid disturbed areas.

In-ground aggregation. Termites appear to forage randomly through the soil, but can quickly recruit large numbers to a new food source. They are thought to regulate the number of foragers at a food source directly according to the mass of susceptible timber available. This behaviour has implications with regard to aggregating large numbers of termites. Large timbers buried in the ground are likely to be found more readily and to amass larger numbers of termites than small blocks of wood.

Aggregation devices include the CSIRO-bait box and plastic conduits.

- **CSIRO-bait-box device:** There are few critical dimensions or materials. Typically, boxes are about 500x300x200mm high and constructed of polystyrene (broccoli box) (Figure 3), polyethylene (worm-farm box) or untreated timber and buried in soil to about 100mm. A lid should seal tightly, to prevent both entry by ants and drying of the contents. Holes in the base of the box permit termite entry. A small window, covered with clear plastic, in the top or end of the box facilitates inspection. A sheet of white paper, blotting or tissue, against the inside of the window may be used to detect termites (once termites have eaten and stained the paper) without disturbing them. Wetted-corrugated cardboard and thin strips of susceptible wood are alternated in layers as the bait substrate. These are easily removed to obtain the termites.

Plastic-conduit devices: Again, there are few critical dimensions or materials. Various do-it-yourself plastic-conduit devices have been used. These include plastic conduit (25mm diameter), perforated with small holes (4mm diameter) drilled every 100mm, with wetted corrugated cardboard inserted. The device is buried (100-150mm depth) in wetted soil diagonally across the under-house area, around the outside of the building, or near active galleries. Plastic “T” pieces are inserted about every metre with vertical tubing (200mm) onto which is attached a small plastic box (200x130x100mm) filled with layers of wetted corrugated cardboard to aggregate termites.

Figure 3. The CSIRO-bait box.

"Stud"-size-pine timber (70x35x2400mm) with slotted-PVC-stormwater pipe (500x90mm diameter, containing timber) positioned in the ground vertically along the stud (Figure 4) has been used successfully. A removable cap aids inspection.

Figure 4. Termite aggregation station with slotted-PVC-stormwater pipe and timber prior to installation.

Alternatively, a 90mm-diameter-plastic-"T"-piece-with-cap unit can be positioned along the stud (Figure 5). PVC-stormwater pipe (500x90mm diameter, containing timber) can be attached to the “T” piece, as necessary.

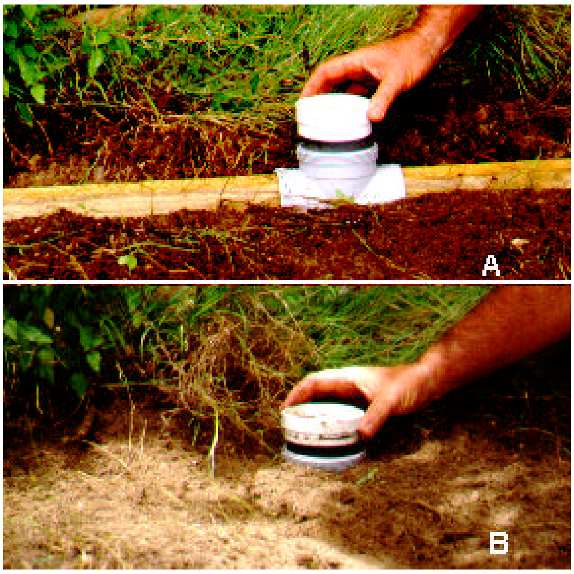

Figure 5. Termite aggregation station with plastic-"T" piece and timber:

A. during installation **B.** installed.

- **Sentricon®:** Dow AgroSciences Australia Ltd have released the Sentricon® Termite Colony Elimination System recently in Australia. The in-ground station has a plastic cylinder (240x45mm diameter, with slots to permit termite entry) which acts as a monitoring device to detect foraging termites. The station contains two small pieces of susceptible wood that can be removed, inspected and replaced, and is placed in an augered hole in the soil. When termites are found in the station, the wood is replaced with a tube containing the bait toxicant in a cellulose matrix. Following the cessation of termite activity, the bait matrix is replaced with wood and monitoring resumed.

Above-ground aggregation. Stations placed in direct contact with infested timbers above-ground can overcome the problem of foraging termites finding the bait. However, access to such activity is not always possible, especially in brick-veneer-slab-on-ground construction.

- **Trees and stumps:** Some termite species build nests in large trees. These trees appear unaffected and, although the whole trunk may be hollow, the only external signs may be hollow broken branches. The presence of termites can be tested readily by drilling the tree. All trees, especially large trees up to 50m from a building should be checked. Using a long auger bit (20mm diameter), several holes should be bored towards the centre of the tree approximately 1m up the trunk. If termites are present or have been, the centre of the trunk will be hollow, or filled with muddy material ("mudgut"). The auger will suddenly penetrate easily as it reaches the hollowed centre.

There are a number of ways for testing whether termites are present in the tree. First, the auger should be examined when it is withdrawn from the tree. If termites are not found on the auger bit, insert a length of dowel into each bore hole. The diameter of the dowel should be slightly smaller than that of the hole, as the sap causes the dowel to swell. Allow at least 150mm of the dowel to protrude to serve as a handle. The dowel should be withdrawn after one to two weeks and checked for signs of termites, which include chewed areas or brown-faecal spotting. Economically-important species of termites found in trees should be treated.

Rectangular plastic containers (lunch boxes, 200x130x70mm deep) have been successfully used as aggregation stations in trees and wooden-house stumps. A 19mm hole was drilled into each of the two longest sides of each container and a 300mm length of 19mm diameter plastic conduit attached through the holes. Four 10mm diameter holes were drilled in the conduit to allow the termites to enter the box. Pieces of wetted single-backed corrugated cardboard and thin strips of susceptible wood were alternated in layers as bait in the box which was covered with a plastic lid. A piece of single-backed corrugated cardboard (350mm long; 45mm wide) was placed in the conduit and one end plugged with a rubber stopper. The box was then connected to the colony by inserting the plastic conduit into a 20mm-diameter hole drilled in the side of the tree or infested stump. Termite entry can be verified by inspection.

- **Sentricon®:** The Dow AgroSciences Australia Ltd Sentricon® Termite Colony Elimination System above-ground station has a plastic container (150x50x90mm deep, with a hole to permit termite entry) which is placed in contact with infested timbers containing active termites. The station can be used to deliver a bait toxicant or to monitor the effectiveness of treatment.

Placement of baits

In Australia, the main problem with baiting techniques against *Coptotermes* spp. has been the inconsistency of termites locating and accepting the baits.

Directed placement of in-ground stations should be in dark, moist, quiet places, rather than at regular intervals around a structure. Primary areas for directed placement include: areas around drains, areas directly adjacent to “wet areas” (bathroom, laundry and kitchen) where plumbing may enter the structure, garden beds adjacent to the structure and around trees or stumps.

With above-ground stations, baits placed in contact with infested timbers are often by-passed and not eaten. Stations placed at feeding sites, rather than on termite “highways”, appear more successful. Electronic devices to detect feeding sites are under development.

Competing food sources for termites usually cannot be removed, so food choices are always available to the termites being baited. In some cases, baits have been pre-decayed with a suitable fungus to enhance bait acceptance. The fungus used varies with the termite species. Similarly, nitrogen additives, principally urea and selected amino acids, have been used to increase the feeding on baits by *Coptotermes* spp.

Toxicant application

The station may contain a bait toxicant or “bait-and-switch” techniques may be employed by replacing the initial bait with one laced with a toxicant. Alternatively, the toxin may be applied topically, usually to several thousand termites, as a dust. Whichever strategy is employed, success depends on the aggregated termites taking a slow-acting toxin back to the nest which eventually kills or suppresses the colony. The toxin-affected individuals must move away from the bait site because accumulation of dead termites will repel other individuals from approaching the bait. Ideally, the toxicant should be non-repellent to termites, or at least be masked by other agents to prevent avoidance behaviour by the foraging termites. The intent is to indirectly starve the termites by killing the gut protozoa or bacteria, or to starve the colony by upsetting the social system or to otherwise interfere with the colony.

Bait toxicant: Recently, several chitin-synthesis inhibitors (for example, hexaflumuron and triflumuron) and metabolic inhibitors (for example, hydramethylnon and sulfluramid) were found to have delayed activity against some termites. As a bait toxicant, they can be used to manage foraging populations of subterranean termite colonies, thereby reducing damage potential.

Dusting: Termites may be aggregated and dusted using a hand blower. Alternatively the aggregated termites may be removed, dusted and then returned to the site of activity. Removal and dusting should be done quickly to avoid stressing the termites and to prevent others from sealing galleries as they retreat. The removed termites are sorted into a large flat container (for example, a photographic-developing tray) by tapping the bait matrix. The termites are then transferred to a jar or plastic bag and gently rolled in the dust. The dusted termites are then released back into the station. The lid of the station is left off until most of the termites have entered their galleries and departed the station. With the “Trojan Termite Technique”, termites are brought from another colony, dusted and released into a station containing aggregated termites. The toxin, in theory, is transferred between termites and through the colony.

Arsenic trioxide is commonly used as a “termite dust”. If used correctly, 1-2g of arsenic trioxide is sufficient to eradicate a colony of termites in 10-20 days. At the end of the period, all treated stations should be carefully reopened and those that are still occupied by active termites should be re-treated.

Arsenic trioxide is highly toxic to humans. For the method to be effective and safe, operator skill is required in judging both the quantities and placement of dust and in handling the toxin and the termites. The treatment must be carried out only by an experienced licensed operator.

Triflumuron is undergoing pre-registration testing as a dust application. Biological control attempts using insect pathogenic bacterial spores, the fungus *Metarhizium anisopliae* and roundworms (nematodes) *Heterorhabdis* spp. and *Steinernema* spp. have had some experimental success. Commercial products are not yet on the Australian market.

Because each termite colony generally forages in its own gallery system isolated from other termite colonies and organisms, it is considered that treating a colony with bait toxicants will not lead to widespread contamination of the soil. It should, therefore, not cause damage to other termite colonies, or other soil-dwelling organisms, of importance in woodland and urban ecosystems.

Conclusion

Termite baiting is still a combination of art and science. Termite-baiting systems are largely in a developmental or refinement phase in Australia. They are most beneficial when used as part of an integrated-pest-management strategy and are not the complete answer to termite management. Colony elimination or suppression should be followed by hazard reduction and regular inspection. A better understanding of termite foraging habits and behaviour will enhance bait-station design and placement for termite aggregation and bait-toxicant application.

Further information can be obtained by contacting:

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Further reading

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