Management Information: ***Coptotermes formosanus***

Raloff (2003) reports on research in heavily infested areas. It has been shown that eradicating the termite is not an easy task. When certain colonies were poisoned, the colony died off completely within 3 months. Within 7 months of the poisoning though each colony had been re-established by neighbouring colonies. *C. formosanus* are aggressive colonizers and Raloff (2003) states that, "Eliminating the occasional nest can be pointless." For treatment to be effective, the author cautions that treatment must be administered widely and repeatedly.

Preventative measures:

Some control methods can be implemented before construction of a new building has even commenced. Termiticides can be applied directly to the soil where the foundation slab is to be poured (Cabrera *et al*. 2001). The authors state that, "Under ideal conditions, protection should last from 5 to 7 years; but under less than ideal conditions or because of improper application it can be much less. The slightest break in the protective barrier is all that is needed for termites to reach a structure." Infestations that occur after a structure has been built can be handled with a variety of methods including the application of termiticides by one of three methods: rodding, drilling, or trenching (Cabrera *et al*. 2001).

A newer method of control involves baiting. Cabrera *et al.* (2002) state that, "Baiting systems provide an alternative to liquid termiticides. Developed in the early 1990s, baiting involves placing bait stations in the soil around the outside of the house. The stations contain small pieces of wood and are checked regularly for termites. When termites are found in a station, the wood is removed and replaced with the bait. The bait is typically a paper-like material that contains a substance that slowly kills the termites. Although this does not kill the termites immediately, it gives them enough time to feed the other termites in the colony. Eventually, all the members of the colony are affected. The termites begin dying and the population of the colony is severely reduced or eliminated."

Brooks *et al.* (2003) report on canine ability to detect subterranean termites. Dogs were trained to detect multiple species of subterranean termites using United States

Customs method of scent detection dog training modified with a food reward. The authors found that dogs were, "98.89% accurate in finding *C. formosanus* termites. Similar accuracy ratings were found for other species of termites.

"Infrared cameras can pick up spots in walls and trees where termite activity is generating heat" (Raloff 2003). "Microwave systems bounce beams through building materials or trees. Where they hit moving objects, such as teeming termites, they register an anomaly. Pest-control operators can then drill into a wall and insert a fiberoptic camera, essentially a laparoscope, to confirm the insects' presence" (Raloff 2003). The author also reports that there are several new acoustic systems on the market that allow eavesdropping on termite noise. There are subtle sounds when the bugs chew and tear wood fibers and when they bang along their tunnels. n a really quiet night, you can hear these guys munching around. And if you tap on a wall, they'll bang their heads presumably drumming an alarm to nest mates (Raloff 2003). Raloff (2003) states that, "For the past 2 years research has been ongoing in the training of dogs to sniff out Formosan termites. In field tests, they perform reliably both inside buildings and out, but they miss Formosans in ceilings and high in walls."

Mankin *et al.* (2000) used a portable, low-frequency acoustic system to detect termite infestations in urban trees. The authors state that, "Termite sounds could be detected also in trunks, but background noise often made it difficult to identify termite signals unambiguously." Mankin *et al.* (2000) conclude that, "The success of these field tests suggests that currently available acoustic systems have considerable potential to detect and monitor hidden infestations of termites in urban trees and around building perimeters in addition to their present uses to detect and monitor termite infestations in buildings."

Chemical control:

Raloff (2003) states that, "Biologists have isolated an oil known as *nootkatone* from the roots of a grass called vetiver. This woody-scented oil, which turned out to have been used commercially to add citrus flavour to sodas, repels Formosan termites for up to a year." Ibrahim *et al.* (2004) investigated the toxicity and behavioral effects of nootkatone and two of its derivatives (1,10-dihydronootkatone and tetrahydronootkatone) to *C. formosanus.* The authors found that, "The acute toxicity

of the *nootkatones* on workers from both colonies increased as the saturation of the molecule increased." *C. formosanus* that were pre-exposed to *nootkatone*-treated sand. The termites experienced abnormal feed and digging behavior and survivorship was reduced 83.5% (Ibrahim *et al.,* 2004). Maistrello *et al.* (2001) found that, "*Nootkatone* acts as a feeding deterrent, inducing starvation that results in almost a complete loss of *Pseudotrichonympha grassii* Koidzumi, the most important flagellate species for cellulose digestion in this termite." Zhu *et al.* (2003) evaluated eight valencenoid derivatives for their repelling activity against *C. formosanus*. The authors found that 1,10-dihydronootkatone was the strongest repellent tested.

Ibrahim *et al.* (2003) studied the toxicity of fipronil against *C. formosanus.* The authors found that, "In topical application assays, fipronil was highly effective against both workers and soldiers at very low doses." Shelton and Grace (2003) achieved sufficient control of *C. formosanus* using two commercially available pesticides; imidacloprid and fipronil. Osbrink and Lax (2003) studied the control of *C. formosanus* using imidacloprid foam. The authors found that after only 6 months from treatment, termite populations had recovered. In some populations growth was suppressed for approximately 15 months, but was then followed by recovery. The results of this study suggest imidacloprid foam is not a efficient control agent of C. formosanus.

Su *et al.* (2004) conducted a study on a new type of termiteicide in which, "Polyethylene film impregnated with lambda-cyhalothrin was placed over a sand plot and covered with a concrete slab to allow insecticide movement into the sand for a period of 5.5 yr. Results demonstrated that sufficient quantities of lambda-cyhalothrin were released front the impregnated polyethylene film into adjacent sand to prevent *C. formosanus* penetration. The impregnated film has less environmental impact than conventional liquid termiticides because the insecticide is held in the polymer. Other advantages include its dual function as a construction moisture barrier and case in verifying its proper installation."

Su *et al.* (2003) conducted research on two chemicals; disodium octaborate tetrahydrate (DOT), and deltamethrin. The authors treated foam board with each chemical and observed the impact on *C. formosanus*. DOT was inefficient at

preventing termite damage, but boards treated with deltamethrin experienced only minor damage from *C. formosanus.* Contrary to the previous study, Kartal *et al.* (2004) took wood treated with disodium octoborate tetrahydrate (DOT), allyl glycidyl ether (AGE), and methyl methacrylate (MMA) and determined that wood specimens treated with DOT and MMA were effective control agents against *C. formosanus.*

There are a number of other studies that report possible chemicals that can be used to combat *C. formosanus*. In their investigation into the insecticide Tropolone, Morita *et al.* (2003) found that it has strong insecticidal activity and has potent insecticidal activity against *C. formosanus*. Tropolone also inhibited the growth of seven other kinds of plant-pathogenic fungi. Boue and Raina (2003) evaluated five plant flavonoids and *C. formosanus's* response to them. The authors found that Apigenin was the most toxic flavonoid and state that, "Biochanin A was most effective in reducing fecundity. Biochanin A is a promising phytochemical with ability to reduce fecundity in primary reproductives of the *C. formosanus's*." Zhu *et al.* (2003) tested Patchouli oil obtained from *Pogostemon cablin*. The oil and its main constituent, patchouli alcohol, were tested for their repellency and toxicity against *C. formosanus.* The authors found that, "Both were found to be toxic and repellent. Unusual tissue destruction was noted inside the exoskeleton of the termite after patchouli alcohol was topically applied to the dorsum. "Zhu *et al.* (2003) reports that, "The terpenoid, cis-nerol was found to be highly toxic to *C. formosanus*." "It appears that terpenoids cause damage to cell membranes resulting in a significant loss of proteins" (Zhu *et al.*, 2003). Change and Cheng (2002) investigated the insecticidal activity of the essential oils from the leaves of *Cinnamomum osmophloeum*. The authors found that, "Among the congeners of cinnamaldehyde examined, cinnamaldehyde has exhibited the strongest termiticidal property."

Biological Control:

Wright *et al.* (2002) report on the pathogenic abilities of *Metarhizium anisopliae* (Metschnikoff) Sorokin and *Beauveria bassiana* (Balsamo) on *C. formosanus.* Previous studies have discovered that small numbers of *B. bassiana* and *M. anisopliae* spores can be spread throughout a *C. formosanus* colony without being detected by the termites. Enzymes and compounds produced by the fungi also can affect their ability to pathogenize insects including termites. Destruxins, cyclic chemical

compounds, have been discovered in *M. anisopliae* (Kodaira, 1961) and are known to have varied effects on insects including neurotoxicity, immunodepressant activity and activation of insect muscle calcium channels (Wahlman and Davidson, 1993). Both fungi in this study are known to produce cuticle-degrading enzymes that permit infection of the host insect without the need for consumption by the target organism."

Raloff (2003) reports that researchers have develop biological warfare agent, the fungus known as *Paecilomyces*. The fungus can be mass produced and in field trials holes were drilled into infested trees and had *Paecilomyces* pumped in. The toxicity of this agent to *C. formosanus* was acute and the fungus grew inside the treated trees, suggesting that treatment could last over extended periods. The fungus also can be transported and taken home to the nest where it can spread and theoretically control the entire colony (Raloff, 2003).

Wang and Powell (2004) studied a new strain of pathogen (*Metarhizium anisopliae* strain: SRRC 2558) from China and its influence on *C. formosanus*. This strain was found to be highly infectious against termites. The authors state that control of *C. formosanus* was achieved when termites were provided with the treated cellulose bait.

Hrdý *et al*. (2001) report that, "Juvenile hormones analogues (JHA) are accepted by insects even at relatively high doses. In termites they induce differentiation of excessive soldiers, an effect that manifests itself only over a period of several days. JHAs may cause disruption of the social structure and ultimately the death of the colony."