PROCEEDINGS

HAWAII AGRICULTURE:
Positioning for Growth

April 5 and 6, 1995

University of Hawaii at Manoa
Honolulu, Hawaii

Sponsored by the
Hawaii Farm Bureau Federation
and the
College of Tropical Agriculture and Human Resources

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Microbial Termite Control

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Introduction

The Formosan subterranean termite, *Coptotermes formosanus* Shiraki, is the most economically important insect pest in the Hawaiian islands. This termite is readily transported by commerce, and is a severe pest of structural lumber, utility poles, and other wood in service in the tropical and subtropical regions of the world.

Subterranean termites (Isoptera: Rhinotermitidae) live in a confined and relatively humid environment that is favorable to fungus growth. Isolates of the entomogenous fungi *Beauveria bassiana* (Balsamo) Vuillemin and *Metarhizium anisopliae* (Metsch.) and compounds extracted and purified from these fungi are under investigation as potential bait toxicants for control of the Formosan subterranean termite.

Collaborators

The research reviewed in this presentation was supported by USDA-ARS Specific Cooperative Agreement No. 58-6615-9-012 and No. 58-6615-4-037, and was performed in collaboration with a number of other scientists at the University of Hawaii:

Virulence of Fungal Isolates. Wendy E. Jones, Department of Horticulture, and Minoru Tamashiro, Department of Entomology (Jones et al. 1995).

Delivery of Pathogenic Fungi. Kathleen M. Delate and Carrie H.M. Tome, Department of Entomology (Delate et al. 1995; Grace, Tome and Delate, in preparation).

Toxins from *Metarhizium*. Magnus C.-J. Wahlman, Bradley S. Davidson (Department of Chemistry), and Robin T. Yamamoto (Department of Entomology) (Grace, Yamamoto, Davidson and Wahlman, in preparation).

Virulence of Fungal Isolates

As shown in Figure 1, lethal doses (LD_{50}, expressed as conidia per termite) of three isolates each of *Beauveria bassiana* (B) and *Metarhizium anisopliae* (M), were determined by topical application of conidial suspensions to individual termite workers. The isolates are identified by their accession numbers in the USDA-ARS Collection of Entomopathogenic Fungi, Ithaca, New York. One of these was known to be pathogenic to the termite *Reticulitermes flavipes* (Kollar) (Grace and Zoberi 1992). We also determined the LD_{95} for each isolate, and the exposure periods to different doses of conidia required for termite mortality (Jones et al. 1995).

To simulate a possible field application method, a follow-up study was performed in which termites in artificial laboratory colonies were "dusted" with fungal conidia. When 10 percent or 20 percent of the termite workers in these groups were dusted with conidia from 14-day old fungal cultures, they successfully transmitted the pathogen to other colony members. The spore loads carried by the dusted termite workers ranged from 600,000 to 8,000,000 conidia per termite, greatly exceeding the LD_{95} range of 490 to 20,000 conidia per termite established in the topical application tests.

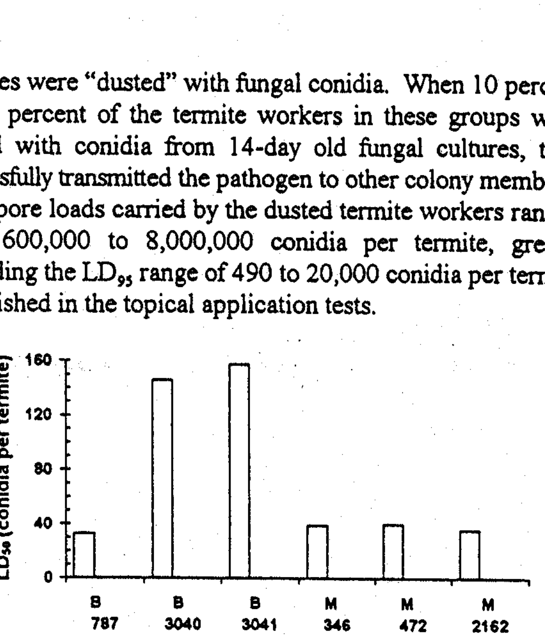

Figure 1. LD_{50} (conidia per termite) of *Beauveria bassiana* and *Metarhizium anisopliae* isolates.

Delivery of Pathogenic Fungi

Foraging subterranean termites could be exposed to a sporulating fungal culture in a bait station inserted either into the soil or into termite galleries in infested wood.

Bait exposure was simulated in a laboratory choice test (Figure 2). A "nest" container with sand and 200 *C. formosanus* (180 workers and 20 soldiers) was connected by a glass tube to a similar "bait" container. A filter paper was coated with agar, inoculated with fungal conidia, incubated 14 days, and placed in the "bait" container. A filter paper coated with agar alone was placed in the "nest" container. In control tests, both filter papers were coated only with agar.

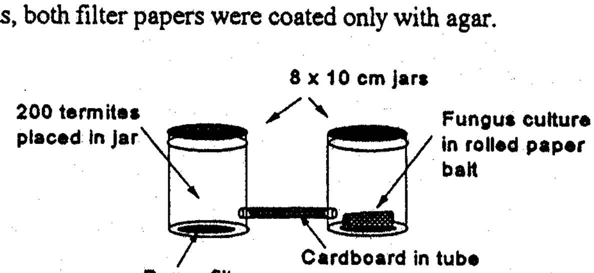

Figure 2. Laboratory assay for evaluating potential of pathogenic fungi as termite baits.

Foraging termites explored the bait containers and fed on the fungus-inoculated papers. As illustrated in Figure 3, termite mortality after six days was greatest with the M 346 isolate. In general, mortality occurs more slowly with *B. bassiana* than with *M. anisopliae*. Slow mortality is desirable so that termites will not die near the bait and repel other foragers.

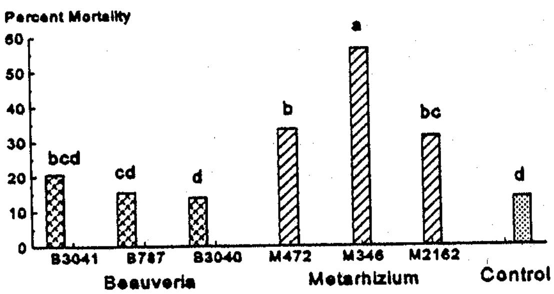

Figure 3. Percentage termite mortality after six days of exposure to fungal baits.

Toxins from *Metarhizium*

Metarhizium anisopliae produces a family of cyclic peptides known as destruxins. Twelve destruxins, including three new compounds (Wahlman and Davidson 1993) were extracted and purified from culture M 2162. Nine of these compounds were isolated in sufficient quantity to permit a comparative study of their toxicity to Formosan subterranean termites.

Each of these nine destruxins was dissolved in acetone and applied to filter papers to achieve a concentration of 0.25 percent (weight/weight). Mortality in groups of termites placed on the papers was recorded daily for one week. The greatest termite mortality occurred from exposure to destruxins A1, A2, or E.

Delivery of Fungal Toxins

If destruxins were sufficiently active and nonrepellent to termite foragers, these compounds might be used in baiting systems for subterranean termite control. The oral toxicity of two of the most active destruxins, A1 and E, to *C. formosanus* was determined in dose-time-mortality tests, and their palatability to the termites was assayed in choice tests of feeding preference. Very similar results were obtained with both destruxins A1 and E.

As illustrated in Figure 4, feeding on filter papers containing from 0.15 percent to 0.33 percent destruxin E (weight/weight) resulted in gradual and consistent termite mortality. However, termites offered a choice of filter papers treated with destruxin E (or destruxin A1) or untreated papers avoided feeding on papers containing either destruxin. In contrast to the no-choice feeding tests (Figure 4) termite mortality after four days in the choice tests did not exceed 6 percent, supporting the conclusion that these compounds are too repellent to the insects to be effective bait toxicants.

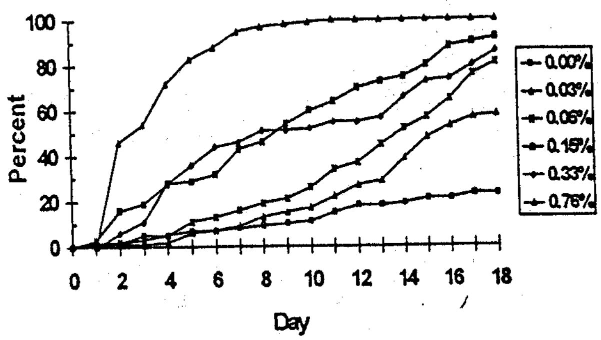

Figure 4. Percentage termite mortality from feeding on papers impregnated with 0.03 to 0.76 percent destruxin E.

Conclusions

Isolates of *B. bassiana* and *M. anisopliae* differ in their virulence to Formosan subterranean termites. *Metarhizium* isolate M 346 and Beauveria isolate B 787 may be particularly promising for use in baiting systems of subterranean termite control. These isolates have low dose-response thresholds, and were not avoided by foraging termites. Conidia were highly infective to termites coming in contact with contaminated foragers.

Purified fungal toxins appear to hold less promise than living fungal cultures and conidia as termite baits, since baits treated with these compounds were avoided by foraging termites. Living fungal cultures offer the distinct advantage of serving as a constant source of inoculum to termite foragers, thus potentially infecting a larger proportion of the colony than would be possible with "dust" applications of conidia alone.

Research on termite-fungal interactions is continuing. As with all baiting methods, successful application of microbial pest control agents to subterranean termite control will be contingent upon development of effective delivery systems.

Literature cited

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