BAIT PREFERENCES AND TOXICITY OF INSECTICIDES TO WHITE-FOOTED ANTS *Technomyrmex albipes* (HYMENOPTERA: FORMICIDAE)

By

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A THESIS PRESENTED TO THE GRADUATE SCHOOL
OF THE UNIVERSITY OF FLORIDA IN PARTIAL FULFILLMENT
OF THE REQUIREMENTS FOR THE DEGREE OF
MASTER OF SCIENCE

UNIVERSITY OF FLORIDA

2003

That one indeed is a man who, today,
dedicateth himself
to the service of the entire human race.
—Bahá'u'lláh

ACKNOWLEDGMENTS

I am deeply grateful to the chair of my committee, Dr. Rudolf H. Scheffrahn, for his endless patience in assisting me through the educational and research processes; and to Dr. William H. Kern who guided me through numerous entomological courses and served on my committee. I also thank Dr. Forest Howard for sharing his knowledge of insects and trees and for allowing us to use the University of Florida's Ft. Lauderdale Research and Education Center's coconut grove. Thanks go to Dr. Thomas Weissling for serving as a member of my committee.

I thank Dr. Robin Giblin-Davis for reviewing my thesis, participating in my final examination, and loaning the laboratory which is now being called the "Ant Lab." I thank his daughter, Julia Giblin-Davis for the time and effort she gave assisting in the experimental work. I thank the following for assisting at the Ant Lab: Vinda Maharajh, Jan Krecek, Leah Jacobson, and Laura Remmen. I also thank Loreto Castro for help with using Excel software.

I thank the Florida Department of Agriculture and Consumer Services for grants that helped fund my research. Thanks also go to Bruce Clary of the University of Florida's Office of Licensing and Technology for help and encouragement in the patenting of the sweet ant bait invented during the research. I thank Dr. Amy A. Ostrom, Scientific Advisor for Akerman, Senterfitt & Eidson, P.A. for her help in the legal aspects of the patenting process.

Last but not least, I thank my wife, Eneida; my son, ‘Alí; and my daughter, Jennifer for their constant encouragement and support.

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May 2003

Chair: Rudolf H. Scheffrahn
Major Department: Entomology and Nematology

White-footed ants (WFA), *Technomyrmex albipes*, were described from Sulawesi, Indonesia and have spread to many parts of the world, including South Florida, where they have become established as a household pest ant. This study describes experiments done at the University of Florida's Fort Lauderdale Research and Education Center to control WFA. Sugars (sucrose, fructose, glucose, and maltose) were offered at 10%, 25%, 40% and 50% (w/v) aqueous solutions in binary choice tests to WFA trailing on buildings. Commercial ant bait carriers and 4 formulae of a proprietary sweet bait, all without active ingredients, were also tested against the sugar solutions. The WFA foragers preferred the proprietary sweet bait Formula 4 to sucrose solutions, and sucrose solutions (≥ 25%) were preferred to other sugars tested. In tests with solutions containing disodium octaborate tetrahydrate (DOT), the proprietary sweet bait with 1% DOT was preferred over a commercial bait with 1% DOT. Additionally, no repellency was observed in 25% sucrose solutions containing up to 7% DOT. Laboratory tests comparing

various treatments on small boxed WFA colonies found that liquid baits with thiamethoxam at 10 ppm in a proprietary sweet bait formula, imidacloprid sweet liquid bait, and Terro commercial ant bait (Senoret Chemical Co. Minneapolis, MN) were significantly more effective than other liquid baits, gels, and residual sprays tested.

CHAPTER 1
INTRODUCTION

Alfred Russel Wallace (1823-1913), who with Charles Darwin (Fig. 1-1) developed the theory of natural selection, traveled throughout Singapore, Malaysia, Indonesia, and New Guinea between 1854 and 1862 (Smith 2000). During these historic travels, Wallace, sometimes called the father of zoogeography (Smith 2000), made keen observations that led to his independent development of the evolutionary theory that he jointly published with Darwin in 1858.

During his sojourn near the village of Tondano, a volcanic highland northeast of Lake Tondano on the island of Celebes (now Sulawesi), Indonesia (Figs. 1-2 and 1-3), Wallace collected specimens of a small, black ant, with whitish tibia. Wallace sent two worker syntypes (specimens of a type series) to Frederick Smith, Esq., assistant in the Zoological Department of the British Museum. In 1861, Smith named the ant *Formica (Tapinoma) albipes* (Smith 1861). The genus *Technomyrmex* was established in 1872 by Mayr (1872). Emery (1888) revised *Tapinoma* to full generic status in the subfamily Dolichoderinae, thereby assigning this ant its current name, *Technomyrmex albipes*.

Wallace's observations of fauna, especially birds, in the region he explored, led him to consider the channel between Bali and Lombok as the divide between two great zoogeographic regions, the Oriental and Australian. This dividing line, which extends

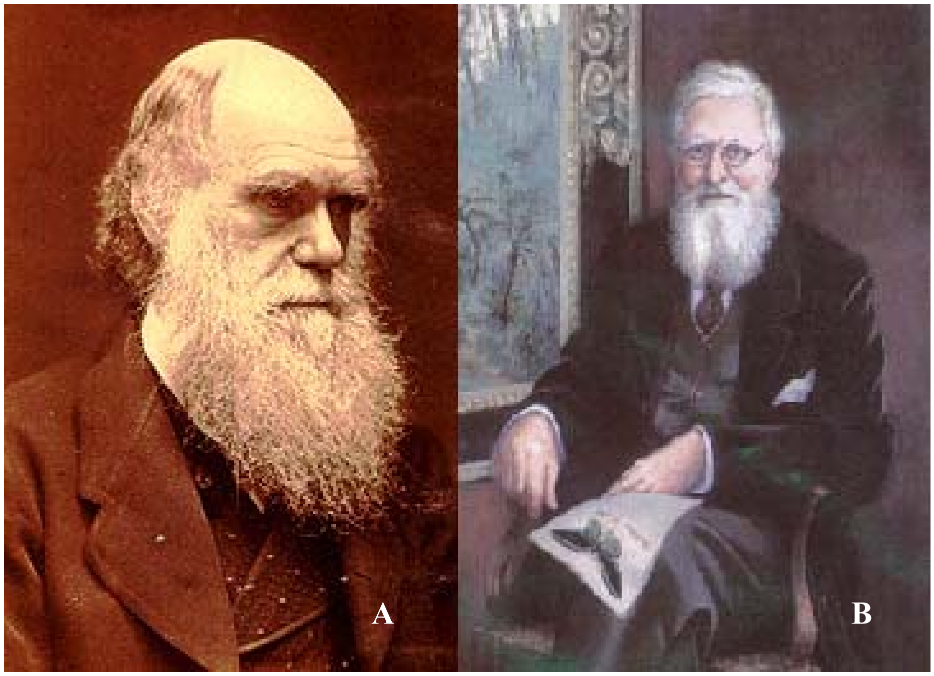

Figure 1-1. Developers of the theory of natural selection. A) Charles Darwin. B) Alfred Russel Wallace. Darwin photo from: Anon. 2002. Charles Darwin. [online] [1 screen]. Available from URL: http://home.vicnet.net.au/~einstein/images/darwin.jpg. Site last visited March 2003. Wallace photo from Anon. 2002. Alfred Russel Wallace. . [online] [1 screen]. Available from URL http://www.linnean.org/img/library_img/Wallace.jpg. Site last visited March 2003.

northward between Borneo and Sulawesi, is still referred to today as *Wallace's Line* (Darlington 1966) (Fig. 1-2). This line is approximately 5 degrees of longitude west of the location where Wallace collected *T. albipes*, which is in turn slightly more than 1 degree north of the equator. Thus, *T. albipes,* collected so near the intersection of Wallace's line and the equator, originates from a unique place in natural history and from a location of great natural diversity.

Distribution

Having coevolved with unknown predators, pathogens, and parasites in its type locality, *T. albipes* has been spread by humans to numerous locations around the world.

Mostly known by the common name "white-footed ant" (WFA), whose origin is unknown (M. Deyrup, personal communication 2003) WFA also has some name variations in other places around the world. In Australia where it "is found in most of the coastal cities" as an "introduced house ant which gives a lot of trouble. . . . almost as bad as the Argentine Ant," it is called the "white-footed house ant" (van Schagen et al. 1994), or the "black house ant" (Clark 1941). Forel (1902) reported WFA in Australia as early as 1902.

The WFA occurs in New Zealand where it is thought to have been introduced in historical times (Cumber 1959). He states that WFAs are an important pest of coastal residential areas in the North Island and around Nelson in the South Island, "where its invading columns with their rancid attending odour are frequently encountered." Forel (1910) reports WFA in the Solomon Islands. *Technomyrmex albipes* is one of the most common ant species on the subtropical island of Okinawa, Japan (Tsuji and Furukawa 1990). Wilson and Taylor (1967) consider *T. albipes* to be "the most widespread of all the Indo-Australian *Technomyrmex*, ranging as a dominant ant from India to eastern Australia and throughout the Pacific, including Melanesia and Micronesia. It is common in Polynesia, particularly Samoa, Tonga and neighboring islands" (Nikitin 1979). Morrison (1996) confirms the presence of WFA in the islands Moorea, Huahine and Bora Bora, part of the Society Islands of French Polynesia. Other Polynesian islands with WFA populations reported by Wilson and Taylor (1967) include the Cook Islands, Tokelau Islands, Tuamotu Islands, Gambier Islands, Marquesas, and Pitcairn Island. Wheeler (1921) reported WFA in Canton, China. The WFA is also established in Sri

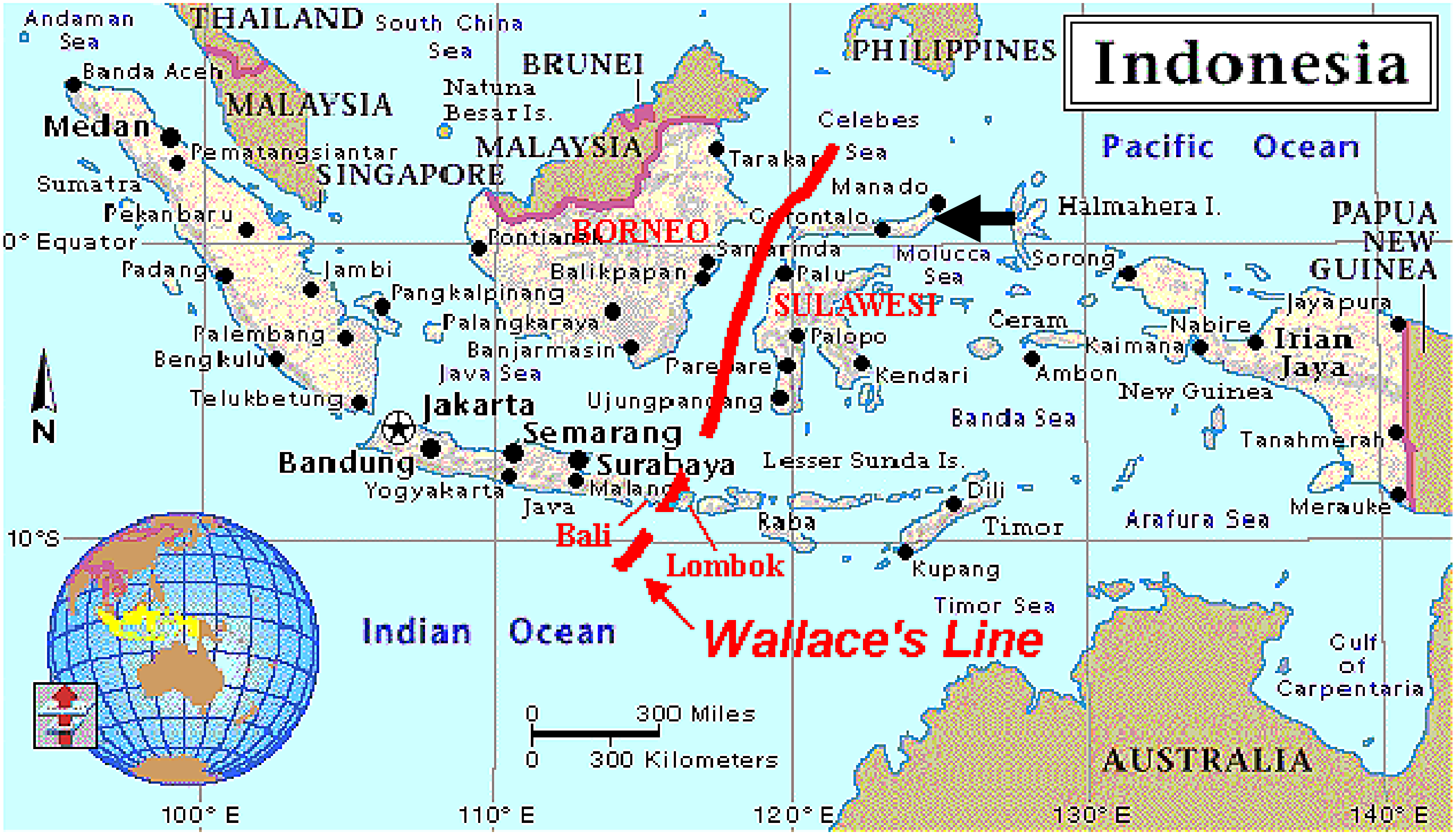

Figure 1-2. *Technomyrmex albipes* type locality: Sulawesi, Indonesia. Arrow indicates type locality. Woodward, S.S. 1997. Wallace's Line. [online] [1 screen]. Available from URL: http://www.radford.edu/~swoodwar/CLASSES/GEOG235/zoogeog/walline.html. Site last visited March 2003

Figure 1-3. Lake Tondano, Sulawesi, Indonesia. Anon. 2000 Sulawesi 2000. [online] [1 screen]. Available from URL: http://www.zool.iastate.edu/~gnaylor/Sulawesi/Introduction.html Site last visited March 2003.

Lanka and Papua New Guinea (see Pest Status below), Madagascar, and New Caledonia (McGlynn 1999). The WFA is established in Saudi Arabia (Collingwood and Agosti 1996) and in South Africa (Prins et al. 1990).

David (1961) describes a black "tree-ant" found in Coimbatore, India, which he refers to as *Technomyrmex* sp. near *albipes*. David describes this ant as black, about 2 mm in length but makes no mention of the lighter colored tibia and tarsi so characteristic of WFA. He describes leaf nests having woven silk and states that these nests are only found in green leaves and not in dry or fading leaves. In describing the nests, which he seems to find only in leaves, David states that there is only 1 queen and that eggs, larvae and pupae are stored in separate sites within the nest. He also describes trophallactic behavior. Considering the lack of mention of the light colored tibia and tarsi, woven silk on leaves, having only 1 queen in a nest, separation of brood elements and a clear trophallactic behavior, David cannot be describing *Technomyrmex albipes*, which does not weave silk, has multiple queens, does not separate brood and does not exhibit obvious signs of trophallaxis.

Regarding a reported 1987 (Holldobler and Wilson 1990, Hedges 1998) establishment of WFA in California, Dr. Phil Ward states:

> Technomyrmex albipes is apparently established in California only under artificial conditions. Some years ago there was a flourishing population around a greenhouse in Golden Gate Park in San Francisco. The workers foraged outside the greenhouse but I suspect that they nested only within it. There are voucher specimens in the Bohart Museum of Entomology (UCDC) P. S. Ward #8795, #8796). I have not examined the population recently. (P. Ward, personal communication 2003)

The WFA is established in the Hawaiian Islands (Reimer 1994) (see Pest Status below), which are the most isolated islands in the world. All ant species found in Hawaii are exotic (Zimmerman 1970). The WFA was first recorded in Hawaii in 1911 by Swezey (1915).

The WFA was first collected in Homestead, Florida, in 1986 (Deyrup 1991). Collections of WFA are now confirmed in Brevard, Broward, Collier, Dade, Hendry, Hillsborough, Lee, Martin, Monroe, Orange, Palm Beach, Pinellas, Polk, St. Lucie, Sarasota, and Seminole Counties, Florida (unpublished, R.H. Scheffrahn)(Fig. 1-4). In Florida, WFA is one of the major nuisance pest species because of its appearance in buildings and landscapes, often in massive numbers. It is impossible to pinpoint its time, mode, or place of entry into Florida, but introduction of the WFA was most likely accidental. Because Homestead, Florida is an agricultural area that has many plant nurseries, many of which import tropical plants, it is speculated that the ant was introduced in plants imported from Asia.

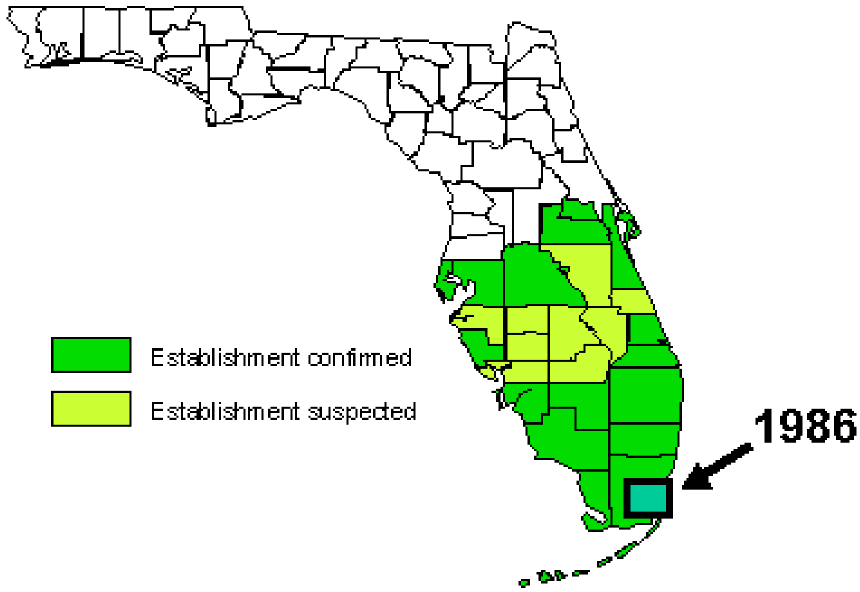

Figure 1-4. Florida. Distribution of *Technomyrmex albipes* in Florida as of October 2002. Fort Lauderdale: R.H. Scheffrahn, University of Florida. 2002.

The WFA will likely saturate urban and suburban habitats in central and south Florida in the next few years, and possibly spread throughout the State. Deyrup et al. (2000) states they are "apparently spreading rapidly." One of the most important means of distribution appears to be transportation of infested residential landscaping plants and materials (Warner, unpubl.).

Description

The WFA is a medium small (2.5 to 3 mm long), black to brownish-black ant with yellowish-white tibia and tarsi (feet) and one petiole (Fig. 1-5). A member of the subfamily Dolichoderinae, WFA have 5 abdominal segments, 12-segmented antennae, few erect hairs, and no sting. Deyrup (1991) adds that WFA can be distinguished from other dolichoderine ants by its lack of a petiolar scale, angulate propodeum, and a conspicuously granulate mesonotum.

Figure 1-5. *Technomyrmex albipes* worker. Photo by R.H. Scheffrahn.

The WFA resembles the Argentine ant, *Linepithema humile* (Mayr) however, the petiole of the Argentine ant has a vertical projection that is lacking on the WFA. In south Florida, WFAs are frequently confused with *Paratrechina bourbonica* (Forel), one of the "Crazy Ants" (Fig. 1-6). *Paratrechina bourbonica* is slightly larger than the WFA, is faster-moving, has more hair, and emits a slight fruity odor when crushed.

The WFA also emits a slight odor. Scientists in Japan report that when “irritated” WFAs release a “sweet smell” which they have identified as benzaldehyde (83%), together with four monoterpene hydrocarbons, an acyclic ketone, and benzyl cyanide (Hayashi and Komae 1980). This might be related to a defense mechanism (consisting of pointing of the gaster) that has been observed when WFAs encounter conspecifics from different nests and other ant species. Pointing of the gaster might involve spraying a chemical in an agonistic display. Other chemicals have been isolated that might be used in defense or in establishing colony odors or trail pheromones. Brophy (1994), using a

Figure 1-6. *Paratrechina bourbonica* worker. Imai, H.T. 1999. A Checklist of the Ants of Australia (Including Christmas Island, Lord Howe Island and Norfolk Island). [online][1 screen] Available from URL: http://nighimai.lab.nig.ac.jp/AZ/Australia/GENUS/Paratrechina_pcd.html. Site last visited March 2003.

gas chromatograph-mass spectrograph (GC-MS), found 2 major components of the venom gland in the gaster of *Technomyrmex albipes* that he identified as dinon-8-enylamine and *N*-hept-6-enylnon-8-enamine.

Life Cycle

Perhaps the key to the WFA's evolutionary success is its ability to reproduce in large numbers, especially considering that it doesn't have the obvious defensive capabilities of many other ants such as a venomous sting; a strong, toxic chemical spray; or a soldier with strong, biting mandibles. Nearly half of the entire WFA colony is composed of fertile, reproductive females called intercastes (Fig. 1-7) that are usually inseminated by wingless males (Yamauchi et al. 1991). Although dealate queens are rare, winged males (Figs. 1-8 and 1-9), which are short-lived, and winged females are released from the colony yearly, usually between July and October in South Florida. These forms copulate during a nuptial flight and found new colonies. Brood (eggs, larvae, and pupae) (Figs. 1-10 through 1-12) begin to develop under the care of the founding queen and the nest population increases. Foragers, which are sterile workers (Yamauchi et al. 1991), bring back food resources that they share with nestmates through the production of non-viable trophic eggs. Only workers perform extranidal activities. The dealate queen is eventually replaced by the intercastes, which can form further new colonies by a process called budding in which the intercastes leave the old colony with other nestmates and brood to establish a new nest site. Unsuccessful attempts were made for over a year to establish colonies in trees by placing tubes containing 100-200 WFA adults and brood (Warner, unpubl.) suggesting that either alates are required for successful colonization or budding must require certain unknown conditions.

Tsuji et al. (1991) describes the castes of WFA as consisting of winged females (queens) and males, several reproductive intercastes and sterile female workers. Winged queens, the largest of all castes in body size, have 3 ocelli and head widths of 0.75 ± 0.02 mm. The three intercastes are the major intercaste, having 3 ocelli, and a head width of 0.65 ± 0.02 mm, the medium intercaste (Fig. 1-7) having 1 ocellus and a head width of 0.63 ± 0.02 mm, and the minor intercaste with no ocelli and a head width of 0.59 ± 0.02 mm. Workers have no ocelli and their head size is also 0.59 ± 0.02. The thorax size and complexity of females decrease from queen down to minor intercaste. The number of ovarioles per ovary also decreases in a similar manner: queens 20.4 ± 2.6, major intercaste 10.8 ± 1.6, medium intercaste 9.2 ± 1.7, and minor intercaste 7.0 ± 1.3. Workers have 2.1 ± 0.5 ovarioles, and this smaller number is the characteristic used to distinguish workers from minor intercastes. Unfortunately, this can only be determined by dissection. Workers have no mature oocytes and therefore do not reproduce but do have trophic oocytes. Tsuji et al. (1991) also state that WFA are unusual in that intercastes perform a reproductive function whereas most intercastes in other species of ants do not. Tsuji et al. (1991) reported that the average population of WFA nests, excluding alates, is 40% intercastes, most of which are minor intercastes, and the rest being workers. Wingless males make up only 0.14% ± 0.4 (mean ± SD). of the population. Ogata et al. (1996) states that it is unlikely that there can be cross mating between winged and wingless reproductives.

Although Yamauchi et al. (1991) and Tsuji and Yamauchi (1994) state that there is no trophallaxis in WFA, behaviors consistent with trophallaxis have been observed on numerous occasions, examples being two adults as well as adults and larvae remaining in a mouth-to-mouth position for several seconds. Yamauchi et al. (1991) state that all nutrient transfer from adults to other colony members is exclusively achieved via trophic eggs that can be produced by all females (dealate queens, intercastes and workers). This would indicate that foragers, which make up about 50% of a mature colony population (Yamauchi et al. 1991) would feed trophic eggs to the non-foraging adult population, which would, in turn, produce trophic eggs to feed the brood. This does not seem to be a highly efficient use of food energy. Additionally, over many months of scrutiny, the feeding of trophic eggs to larvae has never been observed, yet adults and larvae, in a mouth-to-mouth position, have frequently been noted (Warner, unpubl. observations).

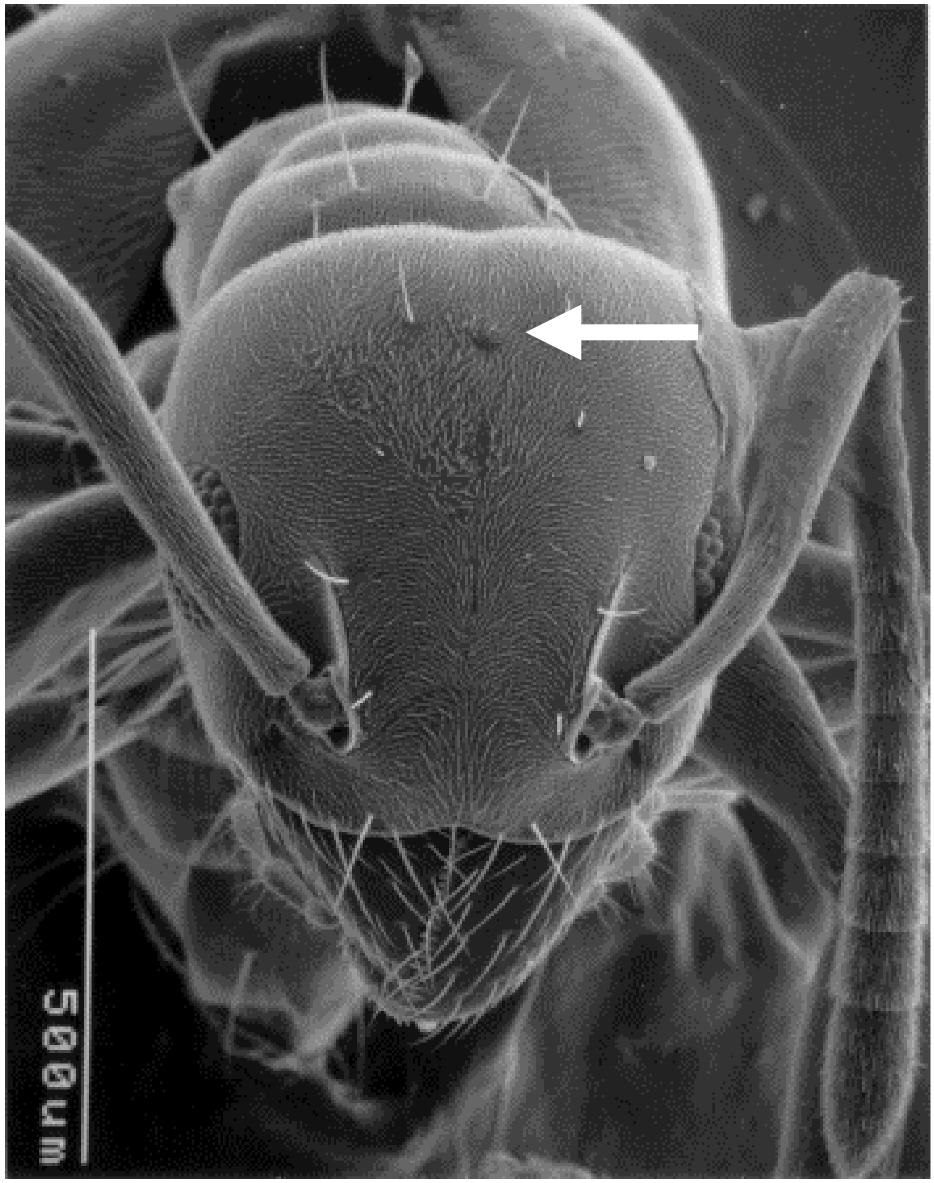

Figure 1-7. Scanning electron micrograph of a WFA female medium intercaste. Arrow: ocellus.

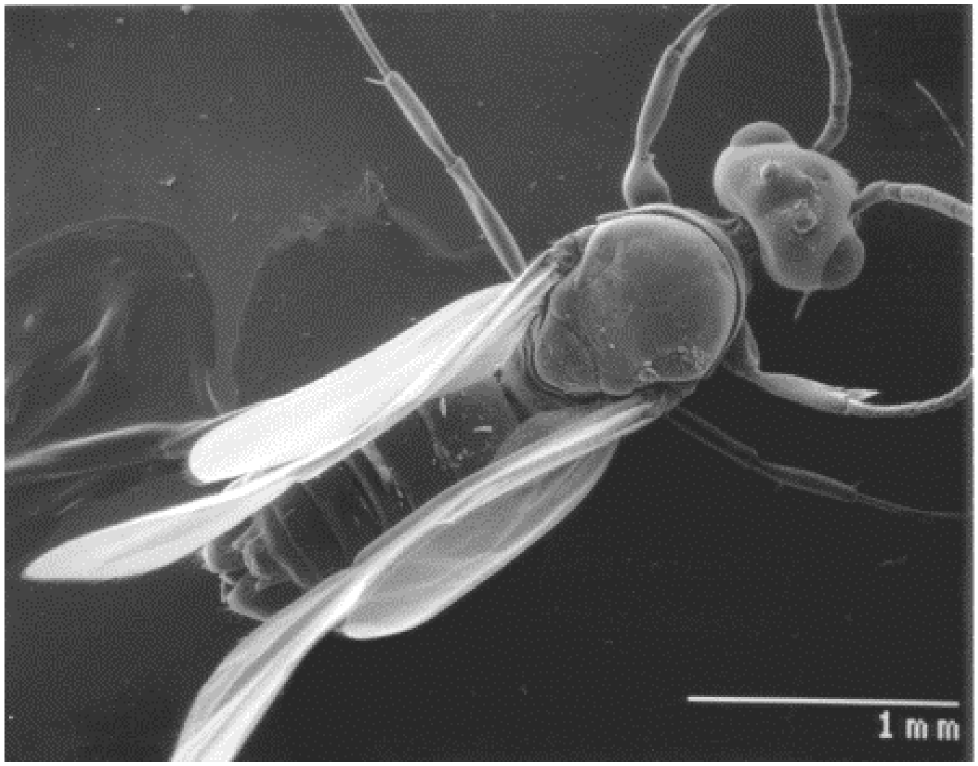

Figure 1-8. Scanning electron micrograph of a WFA male alate.

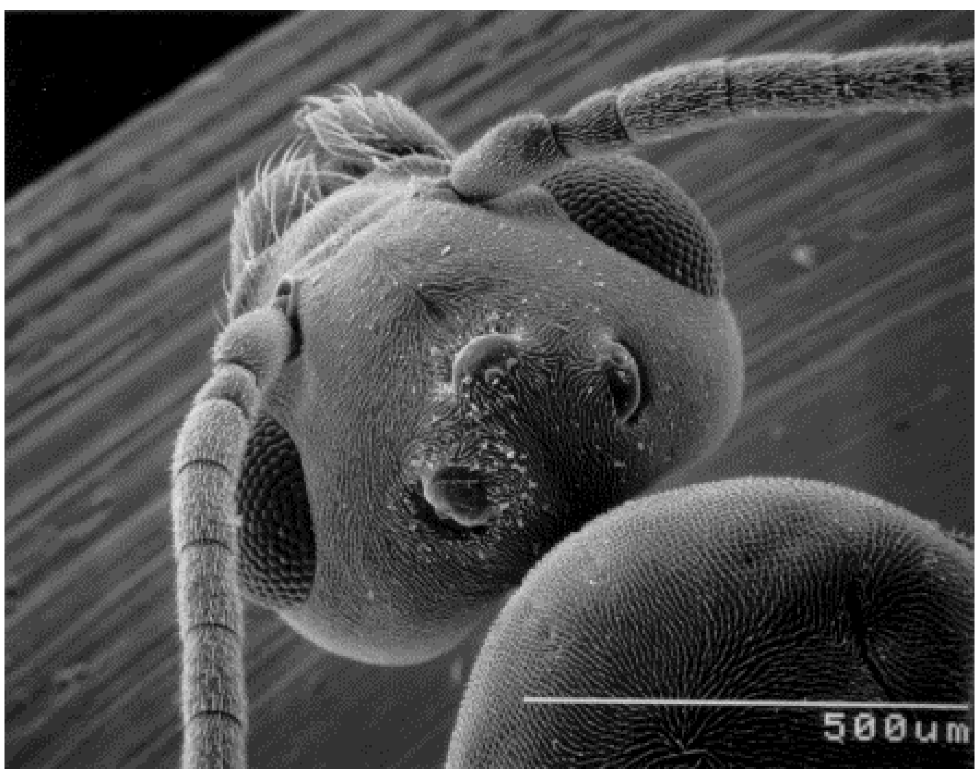

Figure 1-9. Scanning electron micrograph of a WFA male alate head.

Figure 1-10. White-footed ants tending brood.

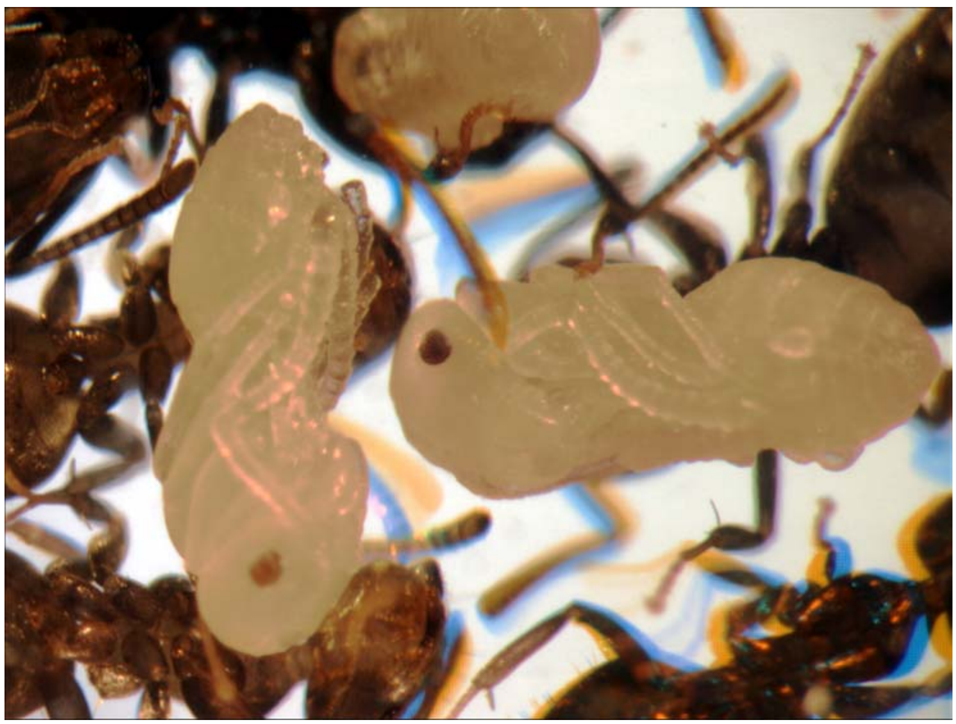

Figure 1-11. White-footed ants tending pupae.

Figure 1-12. White-footed ants tending eggs.

Pest Status

The WFA does not bite or sting, nor has it been reported to cause any structural damage. Colony population estimates vary from 8,000 to 3 million individuals (Tsuji and Yamauchi 1994). WFA colonies are polydomous but have a definite colony boundary and established colonies may last indefinitely (Tsuji et al. 1991).

WFAs are considered by building occupants to be a pest because they are frequently observed foraging in kitchens, bathrooms and the exterior of structures. Little (1984) reports that in New Zealand WFA appear to be attracted to the contact points in light switches and has found dead ants numerous times in switches. The present author has been informed of WFA in electrical switches many times in Florida, but has observed this phenomenon infrequently.

WFA feed on plant nectars and honeydew (Charles 1993, Hata and Hara 1992, Koptur and Truong 1998, Samways et al. 1982, Sulaiman 1997, Wheeler 1921), which is a sweet substance produced by many sap-sucking insects such as aphids, mealybugs, and scales. WFA are known to protect honeydew producers, which has caused problems in agricultural production in some areas of the world. In Sri Lanka, WFA are known to play a major role in spreading the pineapple wilt disease due to their tending of the pink mealybug, *Dysmicoccus brevis* (Cockerell) (Sulaiman 1997). On the other hand, Way and Cammel (1989) report WFAs help control a pest of coconut in Sri Lanka, the coconut caterpillar, *Opisina arenosaella* Walker, by feeding on the caterpillars' eggs. In South African citrus orchards WFA caused localized outbreaks of red scale *Aonidiella aurantii* (Maskell) (Samways et al. 1982). Charles (1993), reports WFA tending mealybugs *Pseudococcus longispinus* (T.-T) in citrus and persimmon orchards. Hawaiian exports of red ginger flowers are often hampered by insect infestations that can cause quarantine rejections at ports. One of the ants which is often found in these flowers and responsible for economic losses is the WFA (Hata et al. 1992 and 1995). In Papua New Guinea, *T. albipes* significantly increases black pod disease (pod rot) in cocoa by vectoring the causal fungus *Phytophthora palmivora* (McGregor and Moxon 1985, Majer 1993).

Foraging and Feeding

Although WFAs feed heavily on sweet liquids (Fig. 1-13) they will, like most ants, also feed on dead insects and other protein. WFAs are commonly found foraging along branches and trunks of trees and shrubs that have nectars and/or sap-sucking insects that produce honeydew. Many WFA foragers emerge from their nests to search for new food resources. Nestmates are recruited to resources by foragers laying trail pheromones. The trail pheromone chemistry remains unknown. Often the same trails are observed between a nest and resource for months at a time, but the trails are not used continuously suggesting a non-volatile component to the trail pheromone. In and on structures, foragers tend to follow lines (Fig. 1-14), such as an edge of an exterior wall panel, which eventually lead to some small opening to the interior of buildings, where foragers become more noticeable to occupants. Frequently WFA's find their way inside wall voids where they follow electrical cables and emerge into various rooms, especially kitchens and bathrooms, where liquid and solid foods can be encountered, resulting in heavy trailing activity.

Figure 1-13. *Technomyrmex albipes* foragers feeding on soda droplet. Photo by R.H. Scheffrahn.

Figure 1-14. *Technomyrmex albipes* foragers trailing on a building. Photo by R.H. Scheffrahn.

Nest Sites

The WFA nests at or above ground level in numerous locations within the landscape, home (Fig.1-15), and suburban woodland habitats. Nests are frequently found in trees and bushes, tree holes, under palm fronds and old petiole bases, under leaves on trees, in loose mulch, under debris, in leaf-litter, both on the ground and in rain gutters, wall voids, and attics. Nests tend to be found outside of structures more than inside. Preferred nest sites provide proximity to moisture and food sources, and protection from predators and environmental extremes. Numerous nests can be said to constitute a colony, but since all neighboring colonies seem to be interconnected, there is probably no simple way to delineate the limits of a single colony.

Figure 1-15. Examples of *Technomyrmex albipes* nesting sites in residential settings.

Leaves of citrus trees infested with various sap-sucking hemipterans tend to curl and eventually drop from the tree. It has been observed that WFA will nest within these curled leaves apparently to be near the honeydew producers (Fig.1-16). Infested leaves dropping onto structures often cause homeowner complaints as ant populations become more noticeable (Warner unpubl. observation). Pemberton (1943) reports WFA nesting in tightly curled leaves of the litchi tree (*Litchi chinensis* Sonn.) at Waiakea, Hawaii. He found these same leaves to be heavily infested with the litchi mite (*Eriophyes litchii* Keifer).

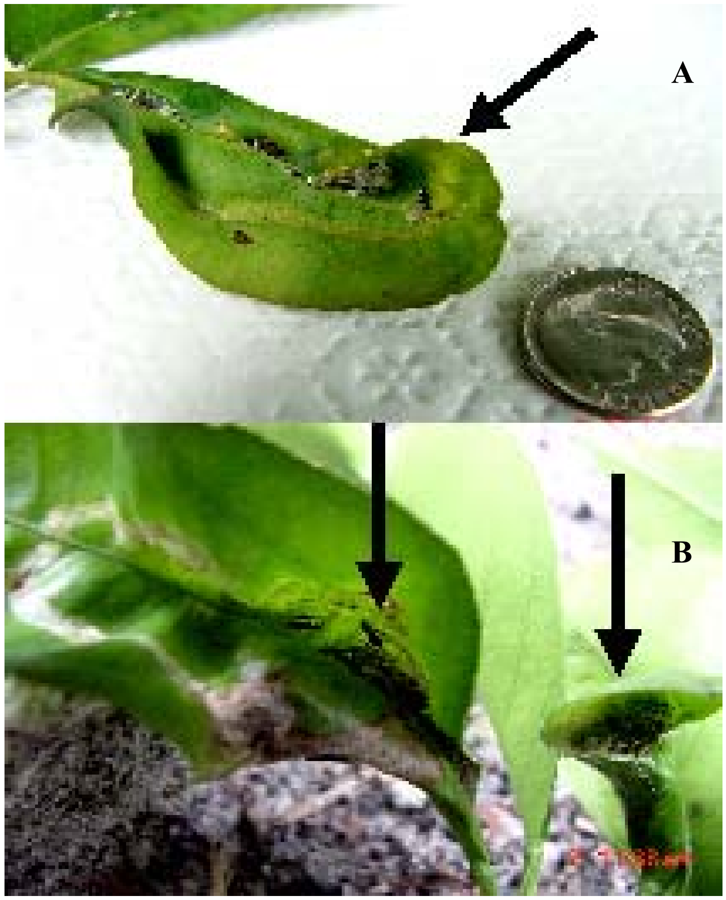

Figure 1-16. Citrus leaf nests. A) curled leaf with lint-covered nest entrance. B) opened nest

Pest Management

The present research was conducted in order to determine the most efficient management techniques for this pest species. Traditionally pest ant control has been accomplished via various insecticidal sprays and dusts, also liquid, solid, and gel baits, which are often combined with cultural practices such as sanitation and exclusion. This study reports on the efficacy of numerous commercial and experimental products and on the preferences the WFA exhibits in relation to several compositions of ant baits.

CHAPTER 2
BAIT PREFERENCE

This study compares the preference of WFA to common and experimental components of liquid ant baits in varying concentrations, with and without disodium octaborate tetrahydrate (DOT), a common ingredient in many commercial ant bait products. Study results may be considered as a guideline for formulating WFA baits. It is obvious that in order for a bait product to be successful in controlling a target pest, it must be more than palatable to the pest, it must be preferred over competing food sources, and it must kill the ants that feed on it. In the following test, a series of products were compared by offering them to WFA which were found foraging on the exterior walls of structures. Since it is well known that WFA will collect plant nectars, and tend honeydew producers, the products that were compared were mostly sugar-based liquid baits that contain the same sugars found in nectars and honeydews (Auclair 1963, Gray 1952, Way 1963, Wilkinson et al. 1997). If an efficacious, non-repellent toxicant is added, bait formulations that are preferred over the sugars found in the ants' natural food sources should therefore have a good chance in controlling at least the foragers that feed on them.

Materials and Methods

Two-choice, random-order preference tests were performed between 27 March and 17 July 2001, on the exterior walls at the University of Florida Fort Lauderdale Research and Education Center, Broward County, FL. Two commercial ready-to-use (RTU) ant baits and several sugar solutions were tested with and without active ingredients, including 1% (w/v) disodium octaborate tetrahydrate (Uncle Albert's Super Smart Ant Bait©, A Safe Pest Eliminators, Inc., Miami, FL) and 1% (w/v) orthoboric acid (Drax Liquidator®, Waterbury Companies, Inc., Waterbury, CT). Sugar water solutions tested included: 10%, 15%, 20%, 25%, 35%, 40%, and 50% (w/v) sucrose (Publix Supermarkets, Lakeland, FL), 25%, 50% fructose (Fisher Scientific, Pittsburgh, PA), and 25% (w/v) maltose (Fisher Scientific). Four artificial nectar-honeydew formulations (proprietary sweet bait, University of Florida, Gainesville, FL, U.S. Provisional Patent Application S/No. 60/401,456 INSECT BAIT, UF#-10836) were also tested against sugars and commercial baits. Solutions of sucrose and disodium octaborate tetrahydrate (DOT) were made from 98% disodium octaborate tetrahydrate (Tim-bor®, U.S. Borax, Los Angeles, CA), in 25% (w/v) aqueous sucrose solution.

Glass shell vials (6-ml capacity) with Titeseal® plastic caps (Fisher Scientific) were modified for use as bait containers by drilling holes (6 mm) in the caps, inserting cotton dental wicks, which minimize bait desiccation and entrapment by ants, adding 4.5-ml bait solution, and using Handi-tak® (Pacer Technology, Rancho Cucamonga, CA) adhesive putty to hold the vials onto walls. Each test consisted of 5 bait vial pairs placed in 2 columns (Fig. 2-1).

Column positions (left and right) were chosen randomly so that ants had an unbiased choice when encountering either of the products being tested. Nine counts of ants on each wick were taken approximately every 30 minutes over 4.5 hours (Fig. 2-2). When the numbers of ants could not be counted visually, digital photographs were taken, and counts were taken from a computer display. Data were analyzed using *t*-Test and Mann-Whitney Rank Sum Tests at $P \leq 0.05$.

Data on feeding times for 30 ants were collected using a stopwatch to determine how much time ants spent at a source of 25% (w/v) aqueous sucrose solution to show turnover during the preference tests.

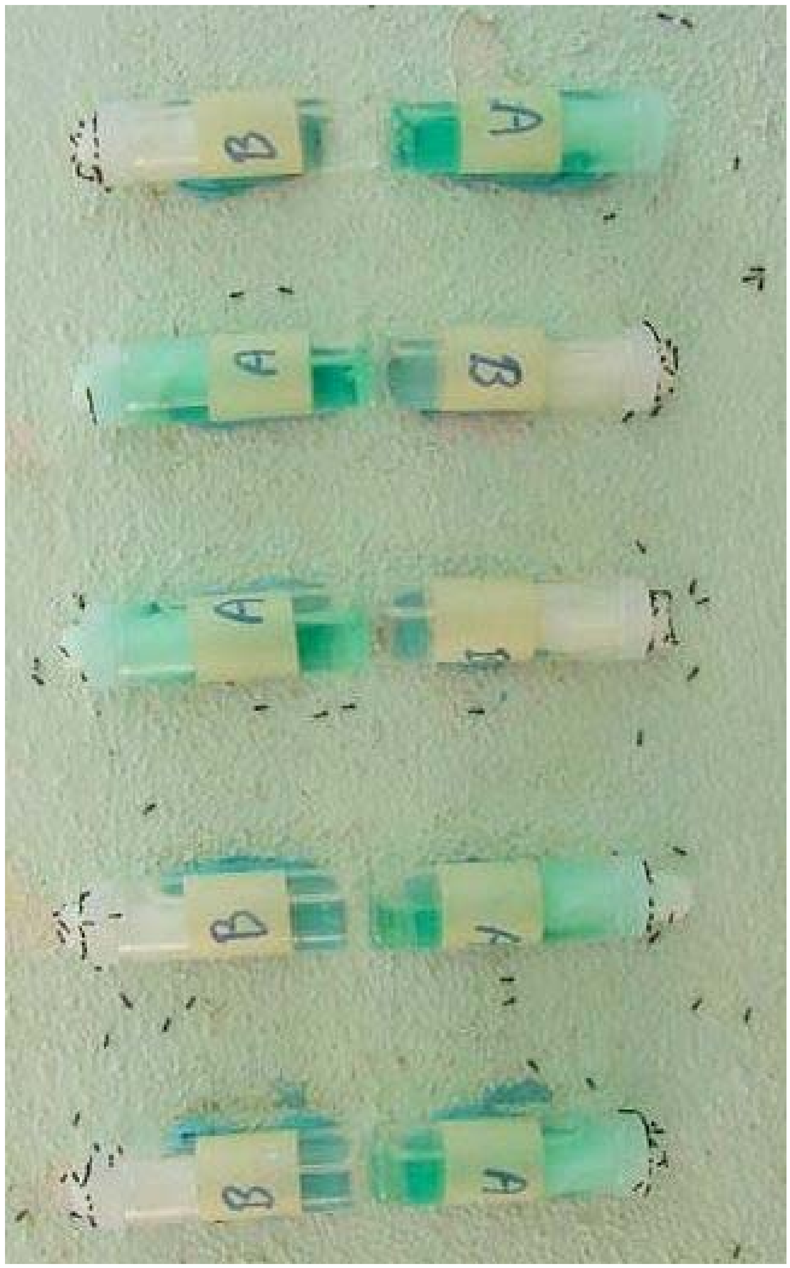

Figure 2-1. Two-choice, random-order preference test with 5 replications. *Technomyrmex albipes* are seen foraging on and between vials.

Figure 2-2. *Technomyrmex albipes* feeding on a wick.

Results

In the present test combined totals of ants feeding on the products less than 100 were weather related factors, such as rain and high temperatures that caused a reduction in ant foraging. Another reason for low counts was a repellency or lack of attractiveness of the product(s). Figure 2-3 shows preference among all paired comparisons tested. Sucrose (10%) was highly preferred ($P < 0.001$) over de-ionized water. Fructose was preferred over maltose at 25% each ($P = 0.033$) while 25% sucrose was preferred over 25% fructose ($P < 0.001$). Sucrose (25%) was preferred over 10, 15 and 20% sucrose. Comparing the proprietary sweet bait (PSB) formulation 1 with sucrose solutions, 40% sucrose was preferred over PSB ($P = 0.002$), but PSB formulation 1 was preferred over 25% sucrose ($P = <0.001$). PSB formulation 3 was preferred over 35% sucrose (P =

0.020) and the PSB formulation 4 was preferred over 40% sucrose (P = 0.015). PSB formulation 4 containing 1% DOT was highly preferred over the commercial product, Uncle Albert's Super Smart Ant Bait having 1% DOT (P = <0.001) (Fig. 2-4).

WFA showed no preference (P = 0.968) between 2% ETOH + 25% sucrose over 25% sucrose alone. There were no significant preferences between 25% sucrose or 25% fructose vs. Uncle Albert's Super Smart Ant Bait (no a.i.) (P = 0.458 and P = 0.057 respectively), 25% fructose vs. Drax (no a.i.) (P = 0.580), or 25% sucrose solutions vs. 1% DOT + 25% sucrose (P = 0.569). Interestingly, there was no significant preference between 25% and 50% sucrose (P = 0.112). This was on a day when, due to rain, few ants were present (test #s 14-19). There were no significant preferences between Drax and 25 or 40 % sucrose with 5% DOT (P = 0.394 and P = 0.245 respectively). There were no significant preferences between PSB formulations 1 and 2 (P = 0.844), also between PSB 2 and 3 (P = 0.713). There were no significant preferences for 25% sucrose vs. 25% glucose (P = 0.463), 25% sucrose vs. 25% maltose (P = 0.852) and 50% fructose vs. 50% glucose (P = 0.817). There were no observed preferences with increasing concentrations of DOT, from 1% to 7% in 1% increments, vs. 25% sucrose (P = 0.218 to 0.916).

The mean time for 30 ants feeding on a sweet bait (25% sucrose) was 96.5 seconds per ant.

Discussion

There are chemical ant control products available including aerosols, which are often used to kill ants in voids, liquid residuals which kill ants on contact and leave a deposit on surfaces crossed by foragers, granular materials which release insecticides slowly onto ant-infested soils and outdoor surfaces, and baits. There has been much

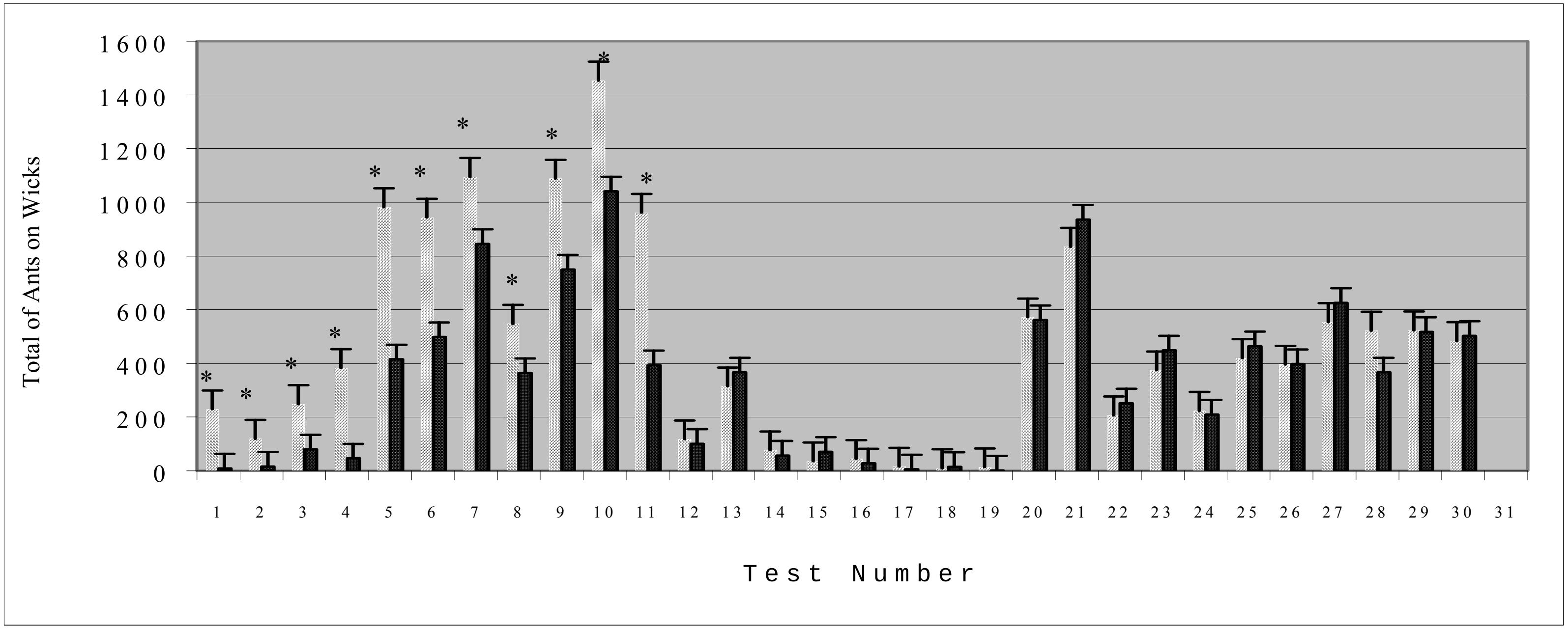

Figure 2-3. White-Footed Ant Binary Choice Preference Tests (total + SE) (n = 5 replicates per pair). [1]10% Sucrose vs. water; [2]25% Fructose vs. 25% Maltose; [3]25% Sucrose vs. 10% Sucrose; [4]25% Sucrose vs. 25% Fructose; [5]25% Sucrose vs. 15% Sucrose; [6]25% Sucrose vs. 20% Sucrose; [7]40% Sucrose vs. PSB1; [8]PSB1 vs. 25% Sucrose; [9]PSB3 vs. 35% Sucrose; [10]PBS4 vs. 40% Sucrose; [11]PSB4 + 1% DOT vs. Uncle Albert's Super Smart Ant Bait; [12]25% Sucrose vs. 25% Sucrose + 2% ETOH; [13]25% Sucrose vs. Uncle Albert's Super Smart Ant Bait (no a.i.); [14]25% Fructose vs. Drax (no a.i.); [15]25% Sucrose vs. 50% Sucrose; [16]25% Fructose vs. Uncle Albert's Super Smart Ant Bait (no a.i.); [17]50% Fructose vs. 50% Glucose; [18]25% Sucrose vs. 25% Maltose; [19]25% Sucrose vs. 25% Glucose; [20]PSB1 vs. PSB2; [21]PSB2 vs. PSB3; [22]Drax vs. 25% Sucrose + 5% DOT; [23]Drax vs. 40% Sucrose + 5% DOT; [24]25% Sucrose vs. 25% Sucrose + 1% DOT; [25]25% Sucrose vs. 25% Sucrose + 2% DOT; [26]25% Sucrose vs. 25% Sucrose + 3% DOT; [27]25% Sucrose vs. 25% Sucrose + 4% DOT; [28]25% Sucrose vs. 25% Sucrose + 5% DOT; [29]25% Sucrose vs. 25% Sucrose + 6% DOT; [30]25% Sucrose vs. 25% Sucrose + 7% DOT. Pairs 1-11 marked with asterisk totals differed significantly at $P < 0.05$. *t*-Test and Mann-Whitney Rank Sum Test.

Figure 2-4. Preference of *Technomyrmex albipes* foragers. A) Proprietary sweet bait Formulation 4 containing 1% DOT was highly preferred over the commercial product, B) Uncle Albert's Super Smart Ant Bait having 1% DOT (Test 11, Fig. 2-4).

interest in the use of baits in recent years for several reasons. Because baits deliver low volumes of toxicants directly to ants, low quantities of toxicants are applied to an area relative to non-bait treatments. Ants which nest in protected places are often unaffected by sprays, but will forage on toxic baits. Baits are easy to apply and require no mixing by the applicator. Additionally, baits do not unduly affect non-target species that do not feed on the bait matrix, and baits can be placed in containers that only allow access to target species.

Baiting has been studied previously with many pest ant species as a means of control (Baker et al.1985; Hooper-Bui and Rust 2000; Klotz and Williams 1995, Klotz and Moss 1996, Klotz et al. 1996, 1997, 1998, 2000; Oi et al. 2000; Silverman and Roulston 2001). Klotz et al. (2000) found that with Argentine ants (*Linepithema humile* Mayr), there was a significant reduction in consumption of sucrose water with >1% w/v boric acid. Based on Klotz et al. (2000), management recommendations for the use of 1% boric acid baits have been made for WFA control (Weissling et al. 1998). Some pest control operators who have followed this guideline have reported unsatisfactory results (Warner, unpublished) suggesting that control methods for one sweet-feeding species are not necessarily universal for all sweet feeders.

The main requisites for a successful ant bait are

- Preferred bait base that will endure long enough to achieve control
- Nonrepellent active ingredient
- Active ingredient acting slow enough to circulate within the colony and/or to allow the recruitment of new foragers
- Active ingredient transferable to nestmates and brood
- Low mammalian toxicity.

When an aqueous liquid bait is being considered, the use of a water-soluble toxicant is preferred because sedimentation and the use of emulsifiers, which might repel ants, are avoided. A somewhat slow rate of mortality is usually considered desirable so that the bait will have time to circulate throughout the ant colony via trophallaxis. In some species of ants that feed other colony members with trophic eggs, such as WFA, the transfer of a toxicant via trophallaxis is probably not an important consideration, although the possibility of toxicant transfer via trophic eggs warrants further investigation. An effective bait that kills a large percentage of workers that would otherwise bring food materials back to the nest, might eventually destroy the nest due to attrition. The viscosity of a bait is another important consideration because as a bait thickens due to water evaporation from exposure to the air and sunlight, ingestion for ants may become more difficult or slower, allowing for less volume consumed or less visitation. Viscous solutions can be compared to gels. In a study of Argentine ant intake of gel and liquid bait formulations (Silverman and Roulston 2001), it was found that ants fed eight times longer on gels but consumed five times less sucrose than workers which fed on a liquid sucrose solution. Syrupy baits might also trap ants.

Baker et al. (1985) performed preference tests for baits on Argentine ants (*L. humile*) and found a preference for 25% sucrose water over 25% honey water in field tests where ants had access to honeydews. Various protein sources (casein hydrolysate, peptones and dried egg) were added to sucrose solutions but only egg white increased bait consumption. Forschler and Evans (1994) assessed bait acceptance and control for Argentine ants, using 0.5% sulfuramid in a peanut butter matrix and 0.9% hyrdamethylnon in an insect pupae-fish matrix, and found that both treatments eliminated foraging activity in 6 weeks. Klotz et al. (1996) evaluated a 1% liquid boric acid bait in 10% sucrose and 0.9% hydramethylnon granular bait in silkworm pupae granules on colonies of ghost ants (*Tapinoma melanocephalum* Fabricius), Argentine and Pharaoh ants (*Monomorium pharaonis* Linnaeus) in no-choice laboratory tests done on small colonies. They found that boric acid baits need to be available to the ants for more than three days to effectively eliminate colonies of the species tested. The hydramethylnon bait eliminated the Pharaoh ant colonies, and reduced the numbers of Argentine ants, but had no effect on *T. melanocephalum.*

Klotz et al. (1998) performed laboratory tests on starved Argentine ants to test recruitment to 10, 25, and 50% sucrose solutions and found significantly higher recruitment with increasing sucrose concentrations. Boric acid (0.2-1%) was added to 10 or 25% sucrose solutions and given to 10 starved ants in Petri dishes. The lethal times (LTs) were not significantly different for 10 and 25% sucrose solutions, whereas LTs were inversely proportional to boric acid concentrations. Klotz et al. (1998) baited 3 buildings infested with Argentine ants. Two of the buildings were baited with 0.5% boric acid in 25% sucrose water and the remaining building with 25% sucrose water as control. After 8-10 weeks an 81% reduction of ants in the treated buildings was observed vs. a 31 % decrease in the untreated buildings. Klotz et al. 1998 stated that a complete elimination of ants was not achieved because of the large initial ant population and the continuous arrival of new colonies.

In another test, 0.5% boric acid in 20% sucrose water provided 100% mortality of Argentine ant workers and queens (M.K. Rust, University of California, Riverside, personal communication cited by Klotz (1998)). This supports the long-accepted hypothesis that a slow-acting toxicant is a prerequisite for an effective ant bait (Stringer et al. 1964), at least for Argentine ants.

Klotz et al. (2000) determined that baits containing >1% boric acid were significantly less preferred by Argentine ants and that there was no significant difference in preference between boric acid and DOT, both inorganic borates. The present study shows that baits containing up to 7% DOT are not repellent to WFA. One advantage of being able to use baits with at least 5% boric acid, is that at the 5% level, boric acid in 25% sucrose will deter microbial growth (unpubl. observation). If this observation is consistent in the field, baits will remain microbe-free for longer periods without having to add antimicrobials which might be repellent to ants.

Klotz et al.(2000) and Klotz and Moss (1996) also conducted toxicity tests using boric acid and sugar solutions against Florida carpenter ants (*Camponotus floridanus* (Buckley)). Test ants were starved for one day before given baits. In this study the author considers that starved ants would feed on baits that might be normally less palatable. Ants used in the current study were not starved prior to testing.

Nectar from 2 flowers, *Brownea* sp. and *Clerodendrum myricoides* (Hochst.), were tested against sugar solutions in a preference test of various ant species by Koptur and Truong (1998). The sugars, in 20% w/v solutions, were fructose, glucose, sucrose and a mixture of the three. Neither of the two plant species tested with WFA were considered by the authors to have "exceptionally attractive nectars". In the test with *Brownea* sp., fructose was found to be significantly preferred by WFA over the nectar or other sugars and in the test with *C. myricoides*, both the nectar and fructose were significantly more preferred over glucose and sucrose, while fructose was not significantly preferred over the mixture of sugars. In these 60-minute trials, each test was repeated 10 times. Counts of ants visiting each drop of material were taken every five minutes, and the means were compared for significant differences. The means reported by Koptur and Truong (1998) are very low: 5 or fewer ants. Furthermore, only 2 nectars were tested for WFA by Koptur and Truong (1998), and these nectars were declared by the authors to not be exceptionally attractive. It was unclear from Koptur and Truong's (1998) study how their results could be applied to our study.

Based on our results, baits containing 25% to 40% sucrose are adequate for most WFA baits, and considering economic factors, 25% sucrose is sufficient and has the further advantage of being less syrupy than those with higher concentrations. Of all products tested, the proprietary sweet bait (PSB) formula 4 bait matrix showed the highest recruitment of WFA (1453) when tested vs. 40% sucrose (1041) ($P = 0.015$). PSB's high preference resulted in high mortality in laboratory tests when a toxicant is added.

CHAPTER 3
LABORATORY EFFICACY TESTS

This chapter describes laboratory studies with boxed colonies of WFA to test the efficacy of a number of commercial and experimental products. Some of the products were purchased over-the-counter (OTC), others were supplied by chemical manufacturers for University of Florida testing, and one other, herein referred to as "PSB" was developed at the University of Florida as a liquid bait for pest ants. The results of the previous preference tests, such as preferred types and concentrations of sugars, were considered in choosing some of the products to be tested in the laboratory. Since PBS had been preferred over 40% sucrose solution, and a well-known commercial product, it was selected for further tests. The less preferred sugars, fructose, glucose and maltose, were not included.

Materials and Methods

White-footed ants (*Technomyrmex albipes*) were collected from a stand of *Phoenix roebelenii* palms at the University of Florida Fort Lauderdale Research and Education Center (Broward Co., FL). Adult ants and brood were collected from nesting sites in palm thatch between 9 a.m. and 3 p.m., when most of the foragers were in the nests. The thatch was placed in a plastic 100-liter garbage pail with a 28-cm hole cut into the center of the lid. The upper portions of the interior sides of the pail were coated with Vaseline® to retard the ants' escape. Ants were separated from thatch material in the laboratory using a plastic container (30 x 23 x 10 cm) which was supported over a water moat (Fig. 3-1). Infested thatch material was taken from the garbage pail, placed in the container, covered with 1 x 15-cm strips of wood and a separator sheet of 3-mm polycarbonate with 2-mm holes. Dripping water from a 2-l tank suspended over the container forced the ants to leave the thatch and enter nesting tubes. Nesting tubes (10 x 75 mm clear polystyrene test tubes) (Fisher Scientific, Pittsburgh, PA), were filled at the bottom with a small cotton ball soaked with sugar water, and completely covered with aluminum foil. Six nesting test tubes were sandwiched between Styrofoam panels and when the tubes were filled with workers and brood, they were placed in a 37-l holding tank provisioned with 25% (w/v) aqueous sucrose and chicken baby food (Chicken & Chicken Broth, Beech-Nut Nutrition Corp., Canajoharie, NY).

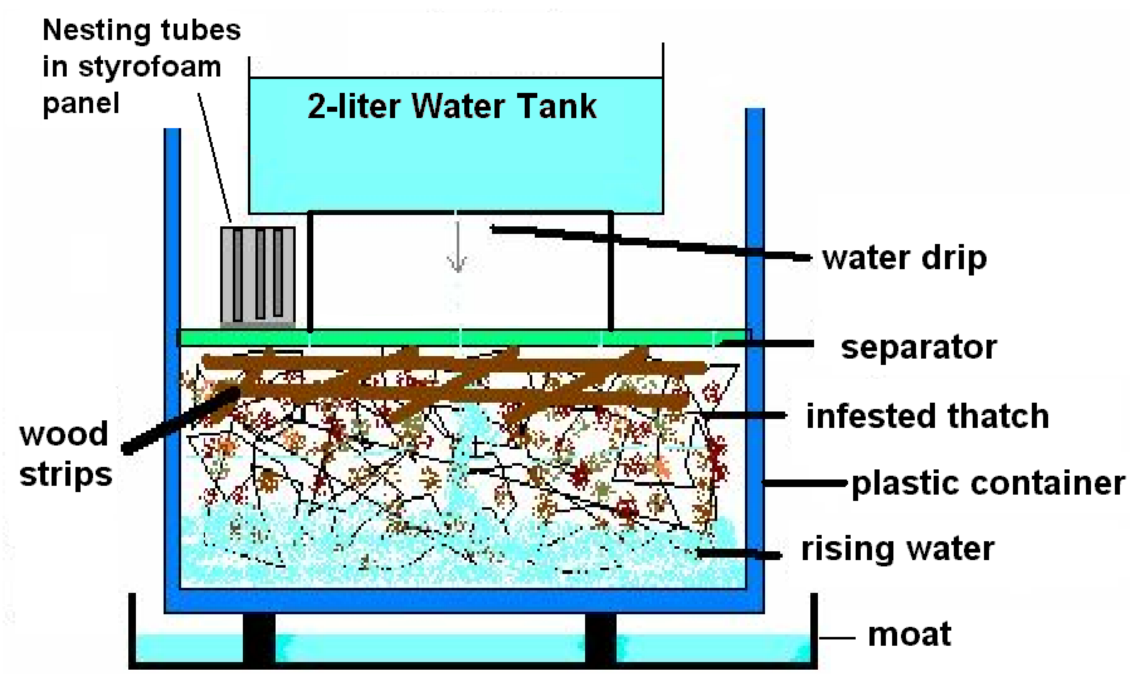

Figure 3-1. Device used to displace ants from palm thatch to nesting tubes

Nalgene™ reusable plastic utility boxes with lids (19 x 16 x 10 mm) (Fisher Scientific, Pittsburgh, PA) were used to hold WFA colonies for laboratory tests (Fig. 3 2). Nesting tubes (Fig. 3-3) with about 200 ants and dozens of brood were placed into each box, held in place with a small amount of Handi-Tak®. Ants were provisioned with water by placing a small cotton ball moistened with approximately 2-ml deionized water in a 41 x 41 x 8 mm plastic weighing boat.

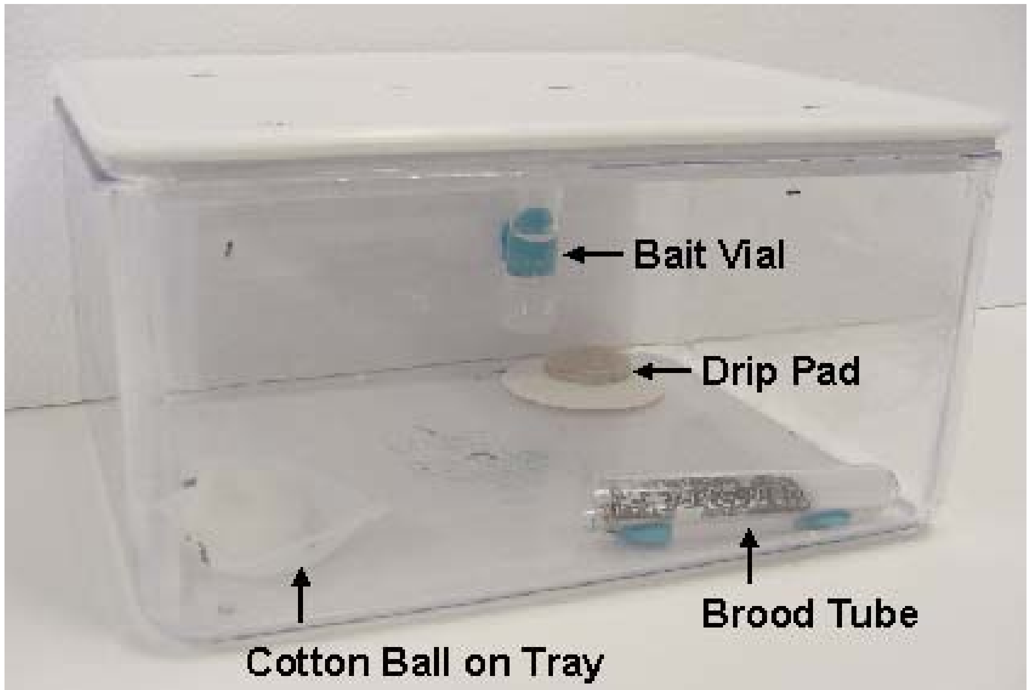

Figure 3-2. Laboratory colony box for WFA efficacy test

Figure 3-3. Brood tube

Sugar water (25% sucrose w/v) and toxic liquid baits (see below) were fed via 6-ml glass shell vials with Titeseal® plastic caps. Five holes (0.86 mm ID) were drilled into the caps. Vials were filled with 4.5 ml bait solution, inverted, and attached to the sides of the boxes with Handi-Tak® (Fig. 3-4). Sugar water was fed *ad libitum* to the ants at all times and supplemented twice weekly by live termites or canned chicken for protein. A felt pad was placed under each vial to catch errant drops and prevent ants from being entrapped in their sticky residue. Ants were allowed to acclimatize in boxes for several weeks. Each day dead ants were removed and replaced with live ants. When ant populations appeared stable, treatments were applied. No ants were added during the experiment.

Figure 3-4. Feeding Tube

Fourteen treatments (5 replicates each, assigned randomly) were applied to the ants in boxes on 8 January 2002 (Fig. 3-5). Some of the products (Table 3-1) were purchased over-the-counter (OTC), others were supplied by chemical manufacturers for University of Florida testing, and one other, herein referred to as “PSB” was developed at the University of Florida as a liquid bait for pest ants. Liquid baits included 1 and 10 ppm thiamethoxam SC (Syngenta Crop Protection, Greensboro, NC) in 25% aqueous sucrose solution, 50 ppm imidacloprid (Bayer Environmental Sciences, Montvale, NJ) in 25% aqueous sucrose solution, 10,000 ppm orthoboric acid (Drax Liquidator®) RTU bait, 54,000 ppm sodium borate decahydrate (Terro Ant Killer II®) (Senoret Chemical Co. Minneapolis, MN) RTU bait, 10,000 ppm disodium octaborate tetrahydrate (Tim-bor®) in proprietary sweet bait (PSB) formula 4. Surface treatments included 600 ppm fipronil (Termidor® SC, Aventis Environmental Science, Montvale, NJ), 800 ppm spinosad, (Conserve® SC, Dow AgroSciences, Indianapolis, IN), and 600 ppm bifenthrin (Talstar®, FMC Corporation, Philadelphia, PA). Additional treatments included 5,000 ppm XR-007 SC (Dow AgroSciences), made into a loose gel using 5,000 ppm Phytagel© (Sigma, St. Louis, MO) in 25% sucrose-water (wt./wt.), and Ultrasonic Pest Repellers (Fig. 3-6)(Lentek International, Inc., Orlando, FL). Untreated controls included 25% sucrose solution, surface and Phytagel© applications. The suspension of XR-007 was placed into a plastic weighing boat (0.5 g), and replaced twice a week or when it desiccated. One corner was cut away to allow for easier access by the ants.

Table 3-1. Products used in laboratory efficacy tests.

Trade names	Generic Name	Chemical Name (IUPAC)	Chemical formula
Conserve	spinosad	Mixture of 50-95% of (2*R*,3a*S*,5a*R*,5b*S*,9*S*,13*S*,14*R*,16a*S*,16b*R*)-2-(6-deoxy-2,3,4-tri-*O*-methyl-α-L-mannopyranosyloxy)-13-(4-dimethylamino-2,3,4,6-tetradeoxy-β-D-erythropyranosyloxy)-9-ethyl-2,3,3a,5a,5b,6,7,9,10,11,12,13,14,15,16a,16b-hexadecahydro-14-methyl-1*H*-8-oxacyclododeca[*b*]*as*-indacene-7,15-dione and 50-5% (2*S*,3a*R*,5a*S*,5b*S*,9*S*,13*S*,14*R*,16a*S*,16b*R*)-2-(6-deoxy-2,3,4-tri-*O*-methyl-α-L-mannopyranosyloxy)-13-(4-dimethylamino-2,3,4,6-tetradeoxy-β-D-erythropyranosyloxy)-9-ethyl-2,3,3a,5a,5b,6,7,9,10,11,12,13,14,15,16a,16b-hexadecahydro-4,14-dimethyl-1*H*-8-oxacyclododeca[*b*]*as*-indacene-7,15-dione	$C_{41}H_{65}NO_{10} + C_{42}H_{67}NO_{10}$
DeltaDust	deltamethrin	(*S*)-α-cyano-3-phenoxybenzyl (1*R*,3*R*)-3-(2,2-dibromovinyl)-2,2-dimethylcyclopropanecarboxylate	$C_{22}H_{19}Br_2NO_3$
Demand	lambda-cyhalothrin	[1a(S*),3a(Z)]-cyano(3-phenoxyphenyl) methyl-3-(2-chloro-3,3,3-trifluoro-1-propenyl)-2,2-dimethylcyclopropanecarboxylate	$C_{23}H_{19}ClF_3NO_3$
Drax	orthoboric acid (boric acid)		H_3BO_3
Merit, Premise, Pre-Empt	imidacloprid	1-(6-chloro-3-pyridylmethyl)-N-nitroimidazolidin-2-ylideneamine, 1-[(6-chloro-3-pyridinyl)methyl]-N-nitro-	$C_9H_{10}ClN_5O_2$

Table 3-1. Continued

Trade names	Generic Name	Chemical Name (IUPAC)	Chemical formula
		2-imidazolidinimine	
Platinum	thiamethoxam	(*EZ*)-3-(2-chloro-1,3-thiazol-5-ylmethyl)-5-methyl-1,3,5-oxadiazinan-4-ylidene(nitro) amine	$C_8H_{10}ClN_5O_3S$
Talstar	bifenthrin	(2-methyl-1,1-biphenyl-3-y1)-methyl-3-(2-chloro-3,3,3-trifluoro-1-propenyl)-2,2-dimethyl cyclopropanecarboxylate	$C_{23}H_{22}ClF_3O_2$
Termidor, Combat, Maxforce	fipronil	(*RS*)-5-amino-1-(2,6-dichloro-α,α,α-trifluoro-*p*-tolyl)-4-trifluoromethylsulfinylpyrazole-3-carbonitrile	$C_{12}H_4Cl_2F_6N_4OS$
Terro	sodium borate decahydrate		$B_4O_7Na_2 \cdot 10H_2O$
Tim-Bor	disodium octaborate tetrahydrate		$Na_2B_8O_{13} \cdot 4H_2O$

Figure 3-5. Products tested

Figure 3-6. Five colony boxes placed near three electronic pest repellers

In a second trial, 15 treatments (5 replicates each, assigned randomly) were applied to the ants in boxes on 16 May 2002. Liquid baits included 10 ppm thiamethoxam in PSB 4 solution, 50 ppm imidacloprid (Pre-Empt©, Bayer Environmental Sciences) RTU bait, 50 ppm imidacloprid ant bait instant granules (Bayer Environmental Sciences) in deionized water (3:1, water: granules), and 54,000 ppm disodium tetraborate decahydrate (Whitmire Micro-Gen Research Laboratories, Inc., St. Louis, MO) RTU ant bait. Surface treatments included 1,200 ppm fipronil (Termidor® SC), 500 ppm indoxacarb (DuPont, Wilmington, DE), 500 ppm deltamethrin (DeltaDust©, Aventis Environmental Science), and 600 ppm lambda cyhalothrin (Demand© CS, Syngenta Crop Protection). Additional treatments included 10 ppm fipronil (Maxforce© Ant Bait Gel, Maxforce Insect Control Systems, Oakland, CA), 100 ppm fipronil (Combat© Quick Kill over-the-counter ant bait stations, Combat Insect Control Systems, Oakland, CA), 5,000 ppm XR-007 SC (Dow AgroSciences), used as a suspension bait in honey-water (1:1), 500 ppm indoxacarb (DuPont, Wilmington, DE) as a suspension in honey-water (1:1), and liquid bait, surface, and gel untreated controls.

Each box to receive a liquid bait treatment also contained a 25% aqueous sucrose vial on the right rear wall, along with the toxic bait vial on the left side of the rear colony box wall (Fig. 3-7). Both vials had felt pads under them. Boxes with gels, had the gels in weighing boats. The boats were on the left side of the box, and the untreated sugar water vials were on the right side. Surface treatments were applied to basswood panels (5 x 7.7 cm), that were previously painted with white acrylic paint, to simulate a typical house exterior (Fig. 3-8). These rectangles covered approximately 20% of the foraging areas of the boxes, which was considered a fair test for the products because a large percentage of the foraging area was affected. It was decided not to put the rectangles between the nesting tubes and the food sources, but to allow the ants to choose where they would forage. For aqueous solutions, 0.17 mL was deposited on panels and distributed evenly with a fine paintbrush previously saturated in solution, and allowed to dry 24 h before exposure to the ants. The dust treatment was applied to panels with a Power-Puff© (Gremar, Inc., West Des Moines, IA) electric duster for 3 seconds. One-half g XR-007 and indoxacarb, in honey were respectively placed into the bulb of 9.3 mL large-tip opening transfer pipettes (having had 8 cm cut back from the tip, Samco©, San Fernando, CA). The treatment preparation of imidacloprid ant bait instant granules (Bayer Environmental Sciences) was done in non-randomized colony boxes because the product was received 1 day after the test had begun.

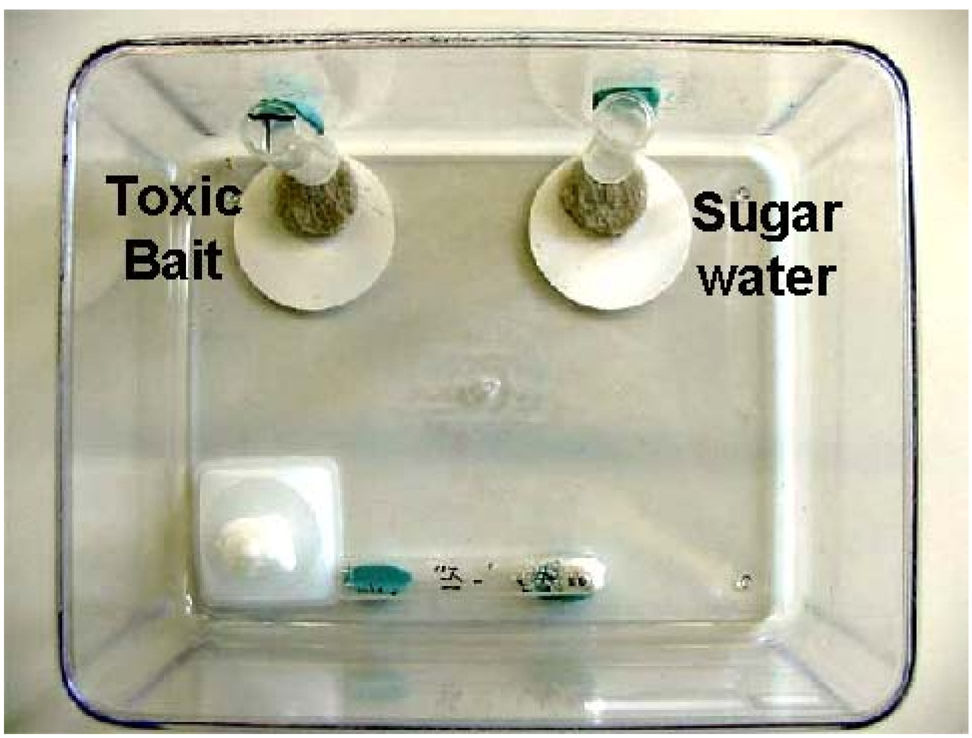

Figure 3-7. Lab boxes. Toxic bait treatment

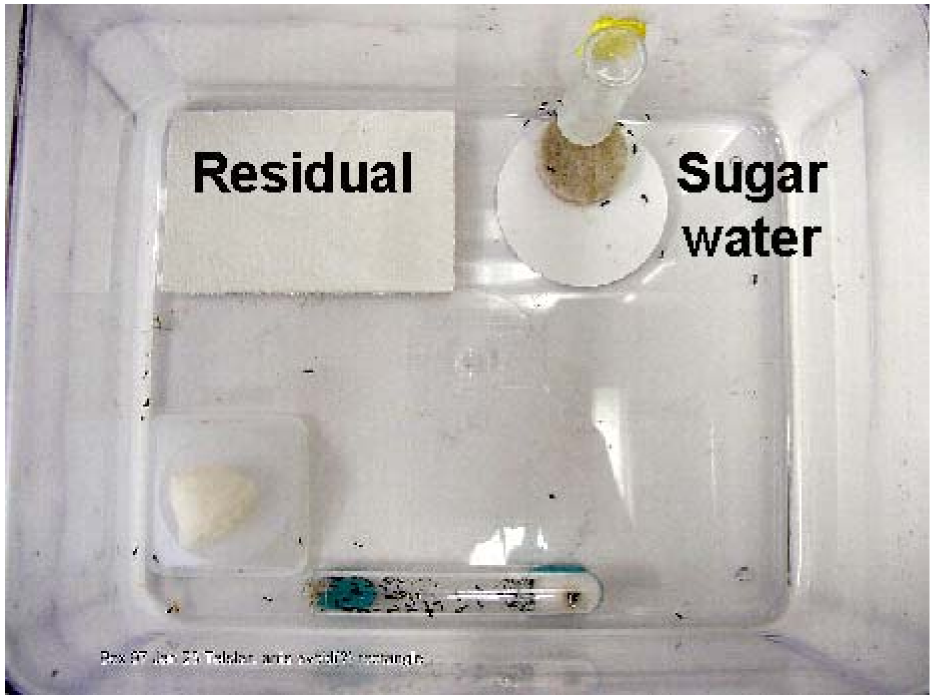

Figure 3-8. Lab boxes. Residual treatment

Dead ants were removed and counted daily for the first week, then twice weekly thereafter. At the end of the experiment, all ants still living were killed with ethanol and counted to determine the total number of ants in each box. It was assumed that the numbers of adults that emerged from pupae in the boxes were not significant over the seven-week trial. Mean percent mortalities were analyzed by ANOVA and general linear model (SAS Institute. 1989. SAS/STAT user's guide, version 6, 4th ed. SAS Institute, Cary, N.C.) and means separated using Student-Newman-Keuls test at P<0.05.

Results

Mortality for the trial that began 8 January 2002 was recorded for 51 days. Mean percent mortality for each treatment at 1, 3, 7, 30 and 51 days after exposure were selected to be representative of the exposure time course and are given in Table 3-2.

One day after exposure, Talstar© had the highest mean mortality (8%), but it was not significantly greater than imidacloprid (5%), thiamethoxam 10 ppm (4%), PSB (4%)

or XR-007 (4%), and only Talsar©'s percent mortality was significantly greater than the controls. Three days after exposure, percent mortality was significantly greater for PSB at 27%, and PSB was significantly greater than all other treatments. On Day 7, the percent mortality for PSB continued to be significantly greater at 49% than all other treatments. The second highest group on Day 7 consists of thiamethoxam 10 ppm (39%) and imidacloprid (30%), which is not significantly greater than Terro© (21%).

After 51 days imidacloprid (91%), PSB (87%), thiamethoxam 10 ppm (84%) and Terro© (76%) were the only treatments that were significantly different than the controls. Treatments not significantly difference than the controls included Talstar, XR007, thimethoxam 1 ppm, Drax, pest repeller, Spinosad, and fipronil.

Table 3-2. Mean percent mortality (± SD) of *Technomyrmex albipes* adults after 1, 3, 7, 30, and 51 days exposure to 14 treatments in a non-forced bioassay, January-February, 2002

	Days				
Treatment	1	3	7	30	51
Talstar 600 ppm	7.60 ± 3.10a	11.69 ± 5.47bcd	14.13 ± 3.92de	28.48 ± 4.44bc	46.77 ± 7.35bc
Imidacloprid 50 ppm	4.92 ± 4.02ab	14.06 ± 7.40b	29.84 ± 10.63bc	78.55 ± 4.83a	90.86 ± 5.43a
Thiamethoxam 10 ppm	4.44 ± 2.26ab	18.33 ± 8.49b	38.81 ± 11.13b	64.77 ± 15.51a	84.40 ± 10.09a
PSB +DOT 10,000 ppm	4.07 ± 3.10ab	26.55 ± 13.36a	48.81 ± 14.86a	76.99 ± 11.43a	86.95 ± 6.05a
XR007 5,000 ppm	3.63 ± 2.17ab	5.44 ± 2.48cd	10.22 ± 4.97de	27.25 ± 8.69bc	42.96 ± 11.78bcd
Terro 54,000 ppm	3.17 ± 4.66b	6.83 ± 5.80cd	21.22 ± 9.22cd	63.94 ± 7.99a	75.51 ± 7.01a
Thiamethoxam 1 ppm	1.66 ± 1.17b	3.64 ± 2.80cd	6.44 ± 4.73e	19.73 ± 9.98c	44.02 ± 13.73bcd
Control bait	1.37 ± 0.73b	2.81 ± 0.98cd	4.72 ± 1.34e	18.33 ± 4.19c	38.82 ± 5.25bcd
Control surface	1.36 ± 0.63b	3.73 ± 1.72cd	5.71 ± 2.05e	24.24 ± 6.65bc	43.99 ± 7.07bcd
Drax 10,000 ppm	1.23 ± 1.16b	4.79 ± 4.14cd	15.37 ± 13.16de	37.68 ± 12.88b	54.18 ± 12.16b
Pest repeller	1.05 ± 0.67b	4.49 ± 4.08cd	6.46 ± 4.24e	14.23 ± 9.05c	27.79 ± 13.20d
Spinosad 800 ppm	1.01 ± 0.87b	2.02 ± 0.83d	3.78 ± 1.85e	16.15 ± 3.78c	34.51 ± 2.42cd
Fipronil 600 ppm	0.98 ± 0.70b	3.46 ± 1.38cd	6.76 ± 2.25e	27.88 ± 5.89bc	53.76 ± 10.84b
Control gel	0.88 ± 0.39b	2.11 ± 0.88d	5.26 ± 2.07e	19.29 ± 7.91c	38.97 ± 12.08bcd
Treatment Effects Statistics					
F	3.99	8.72	17.28	35.84	24.33
df	13, 70	13, 70	13, 70	13, 70	13, 70
P	0.0001	0.0001	0.0001	0.0001	0.0001

[a] Means of 5 replicates, mean = 202.49, SD = 68.41. Means within a column followed by the same letter are not significantly different (Student-Newman-Keuls test) at P = 0.05.

Mortality for the trial that began 16 May 2002 was recorded for 47 days. Mean percent mortality for each treatment at 1, 2, 8, 29 and 47 days after exposure were selected to be representative of the exposure time course and are given in Table 3-3.

The proprietary sweet bait (PSB) + thiamethoxam treatment had the highest mean mortality and yielded significantly greater mortality than all other treatments for the entire testing period. At one day after exposure, only the PSB + thiamethoxam treatment (10%) was significantly greater than any of the controls. Two days after exposure, in addition to PSB + thiamethoxam treatment (20 %), only imidacloprid (Pre-Empt©) (10%) was significantly greater than controls. This same trend is seen in Table 3-2 until Day 29 when imidacloprid instant granules (62%) exceeded imidacloprid (60%). Except for indoxacarb in honey (37%), the remaining treatments were not was significantly greater than any of the controls.

By Day 47 when the trial was concluded, the PSB + thiamethoxam 10 ppm treatment had the highest percent mortality at 100%, which was significantly greater than imidacloprid instant granules (84%) and imidacloprid (Pre-Empt©) (82%). Of the remaining treatments by Day 47 only indoxacarb in honey (52%) was significantly greater than any of the controls. Treatments not significantly difference than the controls included Combat bait stations, Maxforce ant gel, Termidor, indoxacarb surface, Demand CS, DeltaDust, XR007, and Whitmire ant bait.

Table 3-3. Mean percent mortality (± SD) of *Technomyrmex albipes* adults after 1, 2, 8, 29, and 47 days exposure to 15 treatments in a non-forced bioassay, May - July, 2002

	Days				
Treatment	1	2	8	29	47
PSB + Thiamethoxam 10 ppm	9.57 ± 5.59a	19.93 ± 5.03a	62.45 ± 10.79a	97.81 ± 3.36a	99.91 ± 0.21a
Combat Bait Station 100 ppm	4.48 ± 2.56b	7.62 ± 3.94bc	13.66 ± 5.85bc	23.35 ± 7.70cde	32.78 ± 8.25de
Imidacloprid (Exempt) 50 ppm	4.16 ± 2.83bc	10.41 ± 9.31b	21.58 ± 11.63b	60.48 ± 15.40b	81.65 ± 13.18b
Maxforce Ant Gel 10 ppm	2.99 ± 1.67bcd	4.91± 0.98bc	7.60 ± 1.84bc	18.77 ± 4.44de	32.95 ± 10.48de
DPX in Honey 500 ppm	2.93 ± 1.98bcd	5.59 ± 3.16bc	12.31 ± 6.13bc	37.22 ± 7.03c	52.03 ± 8.26c
Termidor 1200 ppm	2.90 ± 2.45bcd	4.10 ± 2.80c	8.01 ± 4.44bc	20.69 ± 5.67de	32.01 ± 7.16de
DPX surface 500 ppm	2.19 ± 2.42bcd	2.56 ± 2.51c	5.61 ± 4.96c	16.59 ± 12.72de	27.87 ± 14.59e
Control Maxforce Gel blank	1.97 ± 1.98bcd	2.75 ± 2.63c	5.95 ± 5.57c	16.90 ± 8.80de	30.24 ± 6.79de
Control surface	1.62 ± 0.62bcd	2.10 ± 0.94c	4.95 ± 2.38c	16.10 ± 5.15de	29.38 ± 4.94de
Demand CS 600 ppm	1.40 ± 1.01bcd	1.95 ± 1.16c	4.27 ± 2.18c	14.44 ± 7.97de	24.69 ± 8.19e
DeltaDust 500 ppm	1.22 ± 1.01bcd	1.48 ± 1.29c	3.81 ± 2.29c	10.53 ± 5.01e	20.64 ± 5.08e
XR007 5,000 ppm	0.98 ± 0.70bcd	1.35 ± 0.91c	4.72 ± 2.47c	14.72 ± 5.14de	29.68 ± 5.85de
Whitmire Ant Bait 54,000 ppm	0.65 ± 1.28cd	2.03 ± 3.78c	15.00 ± 16.92bc	32.71 ± 19.08cd	47.11 ± 20.19cd
Control bait	0.30 ± 0.31d	1.07 ± 1.23c	3.18 ± 2.93c	10.67 ± 6.17e	20.41 ± 6.50e
Imidacloprid IG** 50 ppm	-------------	1.63 ± 1.15c	14.11 ± 8.66bc	61.97 ± 16.01b	84.46 ± 6.73b
Treatment Effects Statistics					
F	8.90	10.30	20.72	31.94	34.93
df	14,75	14,75	14,75	14,75	14,75
P	0.0001	0.0001	0.0001	0.0001	0.0001

[a] Means of 5 replicates, mean = 340.87, SD = 86.48. Means within a column followed by the same letter are not significantly different (Student-Newman-Keuls test) at P = 0.05. **Non-randomized treatment initiated 1 day after other treatments.

Discussion

In this experiment, we compared baits, gels, residuals, and an electronic pest repeller were compared in an efficacy test for WFA control. Much consideration was made in choosing both the products and the formulations of products that were tested. One of the primary concerns in considering commercial products was whether the products seemed to be popular with pest control companies in the area for use against WFA. For the products supplied directly to us by a number of companies, we used, when available, the product-use recommendations of the researchers at those companies. Other products tested were those we purchased over-the-counter, such as the electronic pest repellers, and Combat Quick Kill, both of which are purchased from thousands of retail outlets in this area often as a consumer's alternative to contracting for an expensive pest control service.

The findings that baits were more effective than residual sprays was not surprising, considering the fact that those same spray insecticides have been used against WFA for about a decade with unacceptable results. A very common scenario would be for a pest control operator to spray a person's property to control a WFA infestation, and then be called back a few days later to repeat the application. We were concerned with developing a control procedure that would provide a long-lasting reduction or if possible, complete elimination of the ant population.

When we examine the process of application of a residual product in a residential area to control WFA, we must consider the ant's habitats and food sources. As stated above, WFA nest in numerous locations in the landscaping areas of a property usually feeding on honeydews and nectars, but will often forage into homes where they can find other food sources. Spray applications done by pest controllers are usually done by “power sprayer” which consists of a 75-l tank, a small motor, a 15-30-m hose and a spray wand with a nozzle, or by back-pack or hand pump-sprayers. Area sprayed might include the ant trails, nesting sites, and a perimeter border around the structure, often 1 meter up and 1 meter out from the structure’s base. This application might only take 10 minutes. The tendency has been to omit the difficult-to-reach nesting areas, such as the crowns of high palm trees, nests deep within thick bushes, or many other protected places. From examining many WFA nests, it has been observed that the ants will nest in refugia free of pooling water from precipitation or irrigation. These same areas may be difficult to treat with spray applications. Although ants contacted directly by insecticidal sprays will probably be killed, the results of laboratory tests indicate that even active, fresh insecticidal deposits did not significantly affect mortality.

A bait having a preferred matrix and an efficient toxicant, on the other hand, will draw the ants out from their cryptic nest sites. Since WFA colonies consist of about 50% sterile foraging workers (see Chapter 1), reduction in foragers as a result of feeding on toxic baits should impact resource flow to the non-foraging population.. This may force non-foragers to seek foods in the environment or consume brood. If the 50% mortality level means the elimination of most of the colony’s foragers and therefore a nearly total elimination of the visual population, this may be an acceptable threshold for initial control.

The 4 baits yielding the highest mortality from the January 2002 test were imidacloprid, PSB with DOT, thiamethoxam 10 ppm, and Terro. PSB with DOT reached the 50% mortality level in approximately 8 days, while thiamethoxam and imidacloprid reached this level at about 14 days and Terro at about 20 days. Because thiamethoxam was effective in sucrose solution, it was decided to mix it in the PSB base for the May 2002 test. Proprietary sweet bait with 10 ppm thiamethoxam reached the 50% level at 7 days and 100% mortality at 35 days, and would therefore likely achieve an acceptable level of control in the field.

The residual products tested were not as efficacious as the baits in reaching desirable mortality. Being arboreal ants, it has been observed that they will quickly climb over materials placed in their foraging areas. If the products were at all repellent, the ants would avoid the rectangles and not receive a lethal dose, assuming a lethal dose would be received if they crossed over the treated areas. As seen in the results in January, Fipronil reached 53% at 51 days and Talstar yielded 47%, mortality. In the May trial, fipronil was not successful in achieving an acceptable level of control. In practical terms, 51 days is too long to satisfy property owners experiencing WFA infestations.

The results from the other residuals, baits, gels, one insecticidal dust, and the electronic pest repellers were all unsatisfactory. In a few of the boxes that were placed around the pest repellers, the ants actually moved out of their nesting tubes and nested against the wall closer to the location of the pest repellers.

Due to the efficacy of the proprietary sweet bait formulation with added toxicants, the University of Florida has initiated a Patent for this product.

CHAPTER 4
PROPOSED FIELD WORK

Although experimental testing done under controlled laboratory conditions may portend field efficacy, field experiments are nevertheless needed to verify efficacy. In order to validate laboratory results, it was decided to plan field trials in such a way as to attempt to control as many variables as possible.

A coconut grove located at the University of Florida's Fort Lauderdale Research and Education center, located at 3205 College Avenue, Davie, Florida (26.085^{o} N., 80.238^{o} W), was chosen as the site for field studies for white-footed ant control (Fig. 4 1).

Figure 4-1. University of Florida Fort Lauderdale Research and Education Center's Coconut Grove

Many of the coconut palms at the Center have established populations of WFA. After identifying infested trees, a 4-inch sticky barrier of Tree Tanglefoot (The Tanglefoot Company, Grand Rapids, Michigan) will be applied around each trunk which will keep WFA in the aerial portions of the tree and prevent fire ants and other competitors from climbing into those areas (Fig. 4-2). Boxes with holes will be attached to each tree above the Tanglefoot barrier in which vials of sugar-water and/or toxic baits will be provided for WFA. The boxes will prevent squirrels and other animals from interfering with the experiment. Other trees will be used to compare residual insecticidal treatments. These trees will have 5 inch bands of house paint around the trunk above the boxes, over which different residual products will be sprayed according to label dilutions. Trees with residuals will have sugar-water in the vials in the boxes. Data will be collected by counting numbers of ants on the wicks of vials in all trees, including control trees. The data will be analyzed by ANOVA to compare efficacy of the treatments over a period of time.

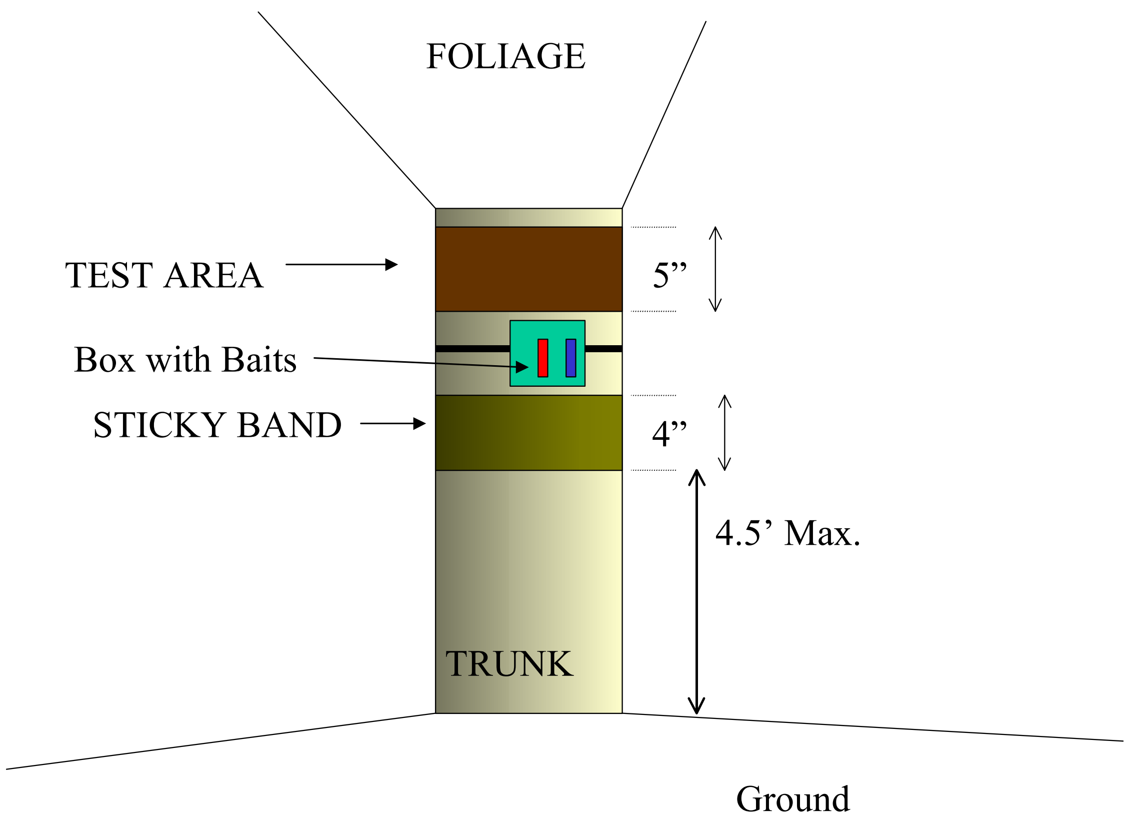

Figure 4-2. Coconut tree schematic

Future field work will probably include testing of products found to be effective in previous tests at residential sites having WFA infestations.

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BIOGRAPHICAL SKETCH

J.R. Warner was born in New York City, raised and educated on Long Island, left on a 10-speed bicycle in 1971 and headed West until the Pacific Ocean caused him to turn South. He stayed in California for 5 years, completing a B.S. degree in Crop Science at California Polytechnic State University in San Luis Obispo. His next stop was Ecuador as a Bahá'í Pioneer, remaining there for nearly 18 years: first as a Peace Corps volunteer, then selling agricultural chemicals, working on shrimp farms, and teaching English and Literature. He moved to Florida with his Ecuadorian family in 1993 and eventually began working in pest control, which, in 2000, led him to begin a master's degree program in entomology at University of Florida's Fort Lauderdale Research and Education Center, concentrating in Urban Entomology. He plans to continue working in pest ant research while pursuing a doctoral degree in Entomology.