Field and Laboratory Evaluation of a Boron-Based Containerized Dual-Bait Formulation Against the Pharaoh Ant, *Monomorium pharaonis* (Hymenoptera: Formicidae)

by

Chow-Yang Lee[1] & Leng-Choy Lee[1,2]

ABSTRACT

A boron-based containerized dual-bait formulation, containing 5.3% boric acid and 4.3% sodium borate, was evaluated against laboratory colonies and field populations of the Pharaoh ant, *Monomorium pharaonis*. Results indicated that the bait successfully reduced 80% brood, 60% worker and 60% queen numbers in laboratory evaluation within two weeks post-treatment. By 4 weeks post-treatment, all brood and queens were killed, leaving only 3% worker ants. Field studies demonstrated >75% reduction in Pharaoh ant counts in treated houses at 1-week, and >90% reduction at 2-week after treatment. The bait efficacy continued to sustain up to 8-week with >75% reduction in ant counts. The potential of the bait in managing household ant population is discussed.

Key words: Pharaoh ant, *Monomorium pharoanis*, baiting, boric acid, sodium borate, laboratory evaluation, field evaluation.

INTRODUCTION

The Pharaoh ant, *Monomorium pharaonis* is an important household ant species in many parts of the world (Yap & Lee 1994; Lee 2000a; Lee 2000b; Lee 2001; Lee & Robinson 2001). Its ability to nest in artificial habitats such as plastic containers, folded papers, PVC pipes, etc. makes it an ubiquitous species in living structures. Besides that, the Pharaoh ant is also a potential mechanical vector of pathogenic organisms (Aleksev *et al.* 1972; Lee 2001) and contaminating agents in health care facilities (Beatson 1972; Bueno & Fowler 1994; Edwards & Baker 1981; Eichler 1990) and food preparative outlets (Lee *et al.* 2001a).

A toxic bait generally consists of four major components (Cherrett & Lewis 1974), namely a food attractant, or pheromone that will increase

[1]Urban Entomology Laboratory, Vector Control Research Unit, School of Biological Sciences, Universiti Sains Malaysia, 11800 Penang, Malaysia. Email: chowyang@usm.my
[1,2]Current address: Dow AgroSciences Asia Sdn Bhd, Level 6 CP Tower, No. 11 Section 16/11, Jalan Damansara, 46350 Petaling Jaya, Selangor, Malaysia.

its palatability and acceptance (Peregrine 1973), a carrier which provides the physical structure or matrix to the bait, a non-repellent toxicant with a delayed action (Stringer *et al.* 1964), and other materials such as emulsifiers and antimicrobial agents. Use of toxic baits to control household ants is gradually becoming a popular method in pest control operations. Baits are generally more effective against household ants, because many residual contact insecticides are repellent (especially those from pyrethroid group) to these insects, particularly the Pharaoh ant (Lee 2001) and Argentine ant (Knight & Rust 1990). In addition, residual contact insecticides do not eliminate or suppress ant population; they are merely intended as barriers to prevent ants from entering into houses (Klotz *et al.* 1997a).

Numerous bait toxicants evaluated had also demonstrated good efficacy against household ants, including those from neurotoxic insecticide (Newton & Coombes 1987; Oi *et al.* 1996; Lee 2000a), stomach poison (Klotz *et al.* 1996; 1997b; 1997c; 2000a), metabolic inhibitor (Williams & Whelan 1992; Forschler & Evans 1994a; 1994b; Oi *et al.* 1994; Blachly & Forschler 1996; Klotz *et al.* 2000b; Lee 2000a) and insect growth regulators (Edward & Clarke 1978; Rupes *et al.* 1978; Newton 1980; Oi *et al.* 1996; 2000; Reimer *et al.* 1991; Vail & Williams 1995; Vail *et al.* 1996; Williams 1990; Williams & Whelan 1992; Williams & Vail 1993; 1994; Williams *et al.* 1999; Lee *et al.* 2001b) groups.

However, one of the major challenges in baiting household ants remains as the 'bait switching' phenomenon as reported by Granovsky & Howell (1983) on the Pharaoh ant. This is due changes in food preference by the ant population. For example, a proteinous- based or sugar-based food that is attractive to one ant colony may not be of interest to the same colony after several months. This can be due to changes in colony development (Erpenbeck 1981), as well as food satiation (Edwards & Abraham 1990). Regulation of nutrient intake is important to the foraging worker ants because queens and larvae have different nutritional requirements. This explained why an ant bait is often not able to continuously provide good control against household ants throughout a whole year.

In order to overcome the problem of changes in food preferences, a dual-module bait formulation containing different nutrients is likely to be a good solution. Here, we report our findings of a field and laboratory evaluation of a boron-based containerized dual-bait formulation, (each containing 5.3% boric acid and 4.3% sodium borate) against the Pharaoh ant, *M. pharaonis*.

MATERIALS AND METHODS

The containerized bait (Mortein Nest Stop® Ant Bait) was supplied by Reckitt Benckiser, Australia. It contained 53 g/kg boric acid and 43 g/kg sodium borate (equivalent to 9.24 g/kg boron) in the form of two inseparable baits, one containing proteinous food attractant (peanut butter) while the other one contained a sugar-based food attractant (honey). Blank baits (without active ingredient) were provided as control bait.

Small colonies of *M. pharaonis* (3 – 6 queens, 70 – 170 worker ants and 0.5 – 0.7 g brood) were each established on an opened small wooden box (35 x 25 x 4 mm). The base of the structure was lined with a graph paper. The nest were then covered with a piece of slide for easy inspection. Upon establishment, the nest was transferred to a test arena (42 x 27 x 9 cm) with 10% sucrose solution and food (boiled egg yolk). The nest was placed at one side of the arena along with the water source while the food was located at one corner of the opposite side. The upper inside surface of the test arena was smeared with a thin layer of fluon to prevent the ants from escape. A small piece of aluminium foil was used to cover the slide surface to keep the nest in dark. After a week of acclimatization, one bait station was placed on the other side of the corner, adjacent to the food. The remaining numbers of worker ants, brood and queens in each nest were examined under a dissecting scope. Examination was done a day prior to the initiation of the experiment (pretreatment), and then on weekly basis up to 4 weeks post-treatment.

Field trial was conducted at Kampung Melayu, a 20-year old apartment block, located at Air Itam, a town located at the heart of Penang Island Malaysia, which has about 480 units of low-cost apartments. Each unit measures 46.5 m^2 and most units have moderate to poor sanitary condition. Screening process to select apartment units with Pharaoh ant infestation were conducted prior to the field trial. About 3 g each of honey and peanut butter were placed onto an index card (7.5 x 6.5 cm) and the card was left on surface area where ant trails were sighted (Lee 2000a). A total of three index cards were placed inside each apartment. After 40 – 60 minutes, each card was checked for presence of Pharaoh ants. The number of ants on each card was counted or estimated. Apartments with a total number of >100 ants were chosen for the trial. Whenever possible, only houses with only Pharaoh ant infestation were used in the trial. A total of 13 houses were chosen for treatment, while five houses were allocated as control houses.

At three days prior to baiting, foraging ant numbers were estimated again using similar method as described above, to determine the pretreatment count. Statistical analysis (*t-test*) was performed to ensure no significant difference existed between the number of ants in pretreatment houses, versus that in the control houses. Baiting was done by placing three containerized baits at locations where visible ant trails were spotted. Post-treatment sampling was conducted using index card at 3-day, 1-, 2-, 4- and 8-week after baiting. The total number of ants sighted at each house was compared with that of the pretreatment count, and percentage reduction was calculated. At 4-week post-treatment, a containerized bait from each house was detached, and opened to estimate for the amount of remaining bait material in the container. The containerized bait were then sealed back and placed back to their original locations. Data were subjected to a nonparametric test (median test) (Siegel & Castellan 1988).

RESULTS AND DISCUSSION

In this study, the containerized bait showed excellent performance against laboratory colonies of the Pharaoh ant (Figs. 1 – 3). Within 2 weeks post-treatment, the bait successfully reduced more than 80% of the brood number, 60% of total worker ants and more than 60% of queen number. At 4th week post-treatment, all queens and brood were eliminated, and only 3% worker ants were left. This clearly indicated that the bait was able to achieve colony elimination. The results obtained concur well with those reported earlier on the performance of boric acid in liquid solution against laboratory colonies of the Pharaoh ants (Klotz *et al.* 1996). After 10-week of exposure to boric acid bait, all colonies tested were eliminated. Another study demonstrated colony elimination of the Pharaoh ant by 5.0% boric acid bait after 7 – 8 weeks (Newton 1980; Newton & Coombes 1987)

The boron-based bait also provided superb efficacy against field populations of the Pharaoh ant (Fig. 4). It significantly ($P < 0.05$) reduced total ant counts on index cards at all sampling dates. At 1-week post-treatment, >75% reduction of ant counts was registered. At 2-week post-treatment, total ant counts dropped to < 10% of the initial pretreatment count. Up to 8-week post-treatment, the bait still managed to sustain a reduction rate of > 75%. Overall, this bait reduced ant trails and foraging ants in all houses treated, when compared to those of the control houses. When using 1% boric acid, Klotz *et al.* (1997c) earlier reported good control of Pharaoh ant infestations in apartment complexes and small buildings after a week of treatment and the significant reduction was further sustained for up to 7 – 8 weeks. On the other hand, Lee (2000a) reported excellent performance of two toxicants, hydramethylnon and fipronil in reducing >80% of total household ant counts after a week of baiting.

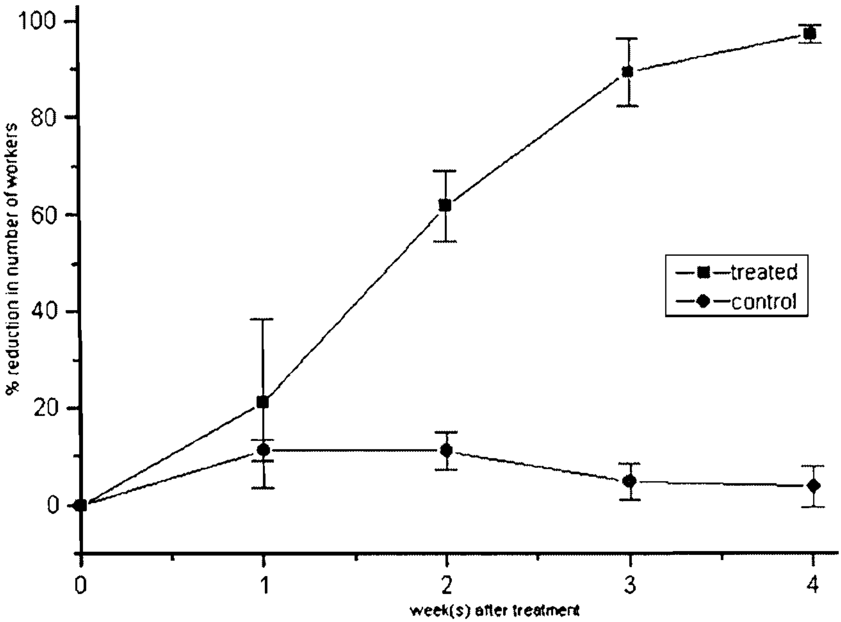

Fig. 1. Laboratory effects of the containerized dual-bait formulation against workers of the Pharaoh ant, *Monomorium pharaonis*.

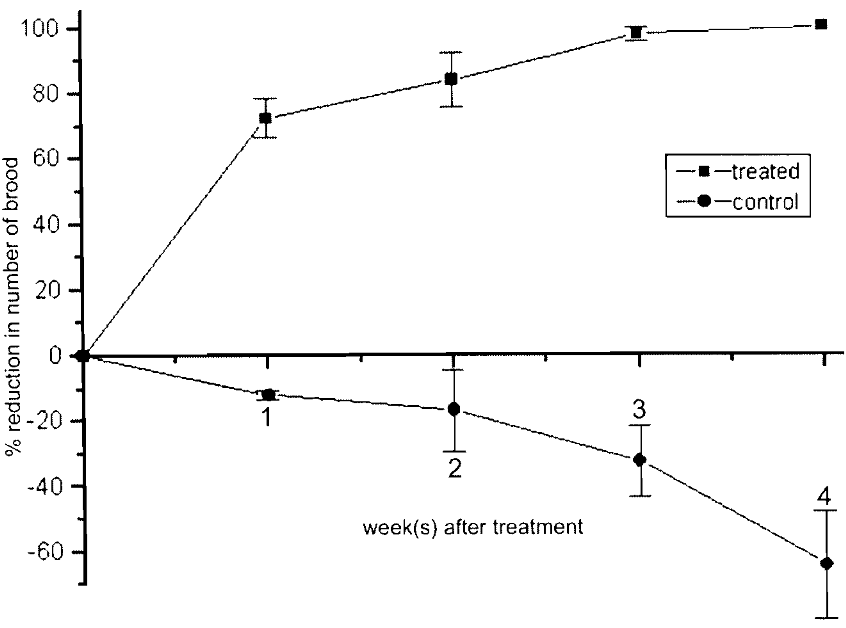

Fig. 2. Laboratory effects of the containerized dual-bait formulation against brood of the Pharaoh ant, *Monomorium pharaonis*.

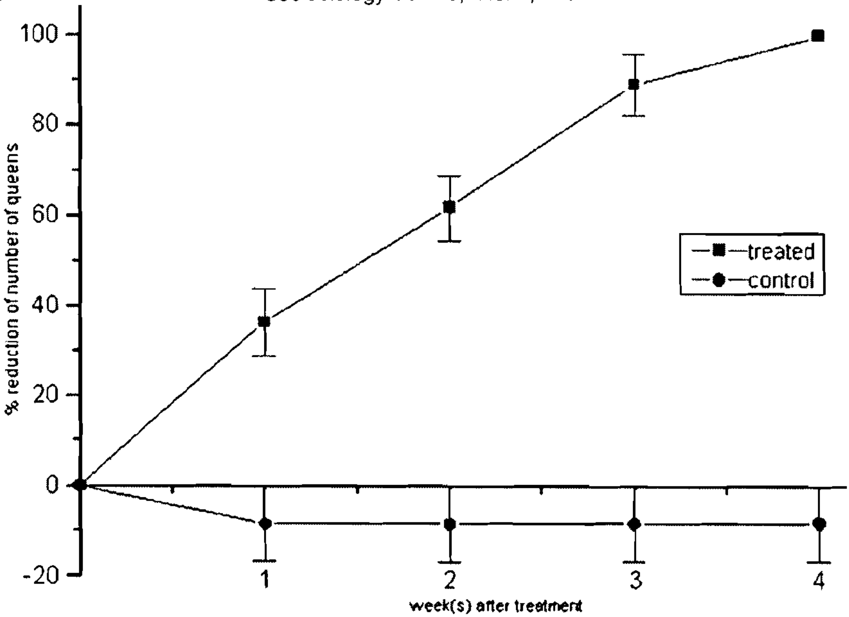

Fig. 3. Laboratory effects of the containerized dual-bait formulation against queens of the Pharaoh ant, *Monomorium pharaonis*.

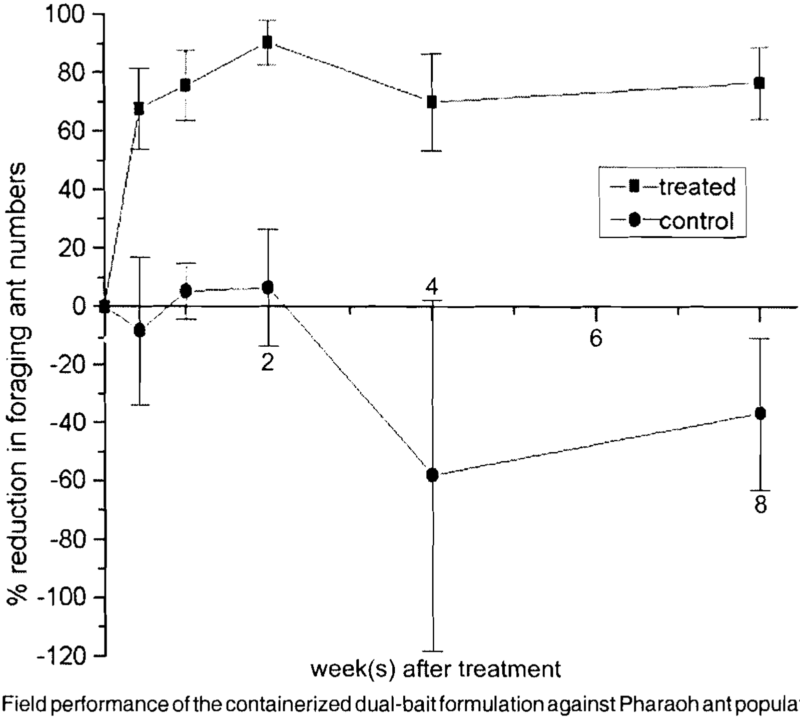

Fig. 4 Field performance of the containerized dual-bait formulation against Pharaoh ant populations.

Boron compounds are excellent toxicants for ant bait, particularly boric acid because it is soluble in water, slow-acting (Klotz & Moss 1996), non-repellent (Knight & Rust 1990) and low in mammalian toxicity (Quarles 1993). This toxicant has been used since late 1800s and early 1900s against household ants (Riley 1889; Rust 1986). Pharaoh ants populations were successfully eliminated with bait formulations containing 5% boric acid (Newton 1980; Newton & Coombes 1987). Wright & Stout (1978) proposed 2% boric acid in either liquid, or solid bait formulation. Klotz & Moss (1996) however, felt that higher concentrations of boric acid will not allow ample time for the bait to be passed to other colony members because foraging ants tend to die quickly after consuming the bait. It is essential to have the ants feeding on the bait longer than 3 days period, because the toxicant's effect is delayed and cumulative (Klotz *et al.* 1996; 1997a; 1997b). Recent better understanding of ant biology and behavior have promoted more usages of these compounds with better or more suitable bait attractants, particularly those in liquid and semiliquid formulations (Klotz *et al.* 1996; 1997c; 2000a). The concentration of boric acid and sodium borate used in the present bait formulation is likely to have taken into consideration of all these factors.

A total of 18 containerized baits (13 treatment and 5 control bait stations) were detached and opened at 4th week post-treatment. It was observed that about 45% and 90% of treatment and control bait materials, respectively, had been consumed (mostly on the protein-based compartment). This indicated the attractiveness and palatability of the bait matrix to the Pharaoh ant populations.

Despite seeing a good control of the Pharaoh ant in treatment houses, a few other household ant species (*Paratrechina longicornis*, *Tapinoma melanocephalum*, *Tapinoma indicum* and *Pheidole megacephala*) were observed on 1 – 2 index cards in several houses after 4-week post-treatment. We speculate that this was due to a territorial phenomenon, whereby upon reduction of a more dominant Pharaoh ant, other ant species were able to forage at a wider area for food. This likely explains why other species of ants were not found, or found at a very low number when the index cards were placed during the initial sampling dates (prior to 4th week). We have also recorded similar observation when baiting with imidacloprid gel against the Pharaoh ant (C.Y. Lee & L.C. Lee, unpublished). It was unknown though the effect of this bait on these ant species, which was not measured in this study.

In conclusion, the boron-based containerized dual-bait formulation demonstrated excellent efficacy against laboratory and field populations of the Pharaoh ant. More studies should be conducted in future to determine the effects of this compound on other important peridomestic household ant species such as *Paratrechina longicornis* (crazy ant), *Solenopsis geminata* (tropical fire ant) and *Tapinoma melanocephalum* (ghost ant).

ACKNOWLEDGMENTS

The authors thank J.P.S. Na, S.Y. Lim, E. Bakar, H. Yahaya and V. Somasundaram for field assistance, and Reckitt Benckiser (Australia) for supply of baits for this study.

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