Oral Toxicity of a Boric Acid - Sucrose Water Bait to Florida Carpenter Ants (Hymenoptera: Formicidae)[1]

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ABSTRACT The oral toxicity of boric acid to the Florida carpenter ant, *Camponotus abdominalis floridanus* (Buckley), was evaluated in laboratory tests. The ants were provided a sucrose water-based bait containing various concentrations of boric acid. Over the dosage range from 0.02 M (0.13% w/v) to 0.50 M (3.13% w/v) boric acid, median lethal times (LT_{50}s) (95% CL) ranged from 9.7 (8.1-13.3) days to 1.5 (1.2-1.7) days. Over the same dosage range (0.02 M to 0.50 M), LT_{90}s (95% CL) ranged from 27.1 (18.0-59.5) days to 4.2 (3.6-5.1) days. Some of the advantages of using boric acid as a bait toxicant for ants include its delayed activity and its solubility in water.

KEY WORDS Insecta, *Camponotus abdominalis floridanus,* control, borate

Historically, boric acid has been used in structural pest control for ants and cockroaches since the early 1900's (Rust 1986). More recent applications of boric acid ant baits have been largely encouraging. For the Pharaoh ant, *Monomorium pharaonis* (L.), Wright and Stout (1978) recommended using 2% boric acid in either a liquid or solid bait. Newton (1980) reported successful control of Pharoah ants in both laboratory and field tests with formulations of 5 and 7% boric acid. In field tests, Hagmann (1982) attained control of pavement ants, *Tetramorium caespitum* (L.), thief ants, *Solenopsis molesta* (Say), and little black ants, *M. minimum* (Buckley), witha 5.4% borax bait. Olkowski et al. (1991) recommended a 2% boric acid and sugar-water bait for Argentine ants, *Linepithema humile* (Mayr). Rust and Knight (1990), however, in laboratory arena tests found that a commercial 5% boric acid gel bait was unsuccessful in controlling colonies of Argentine ants. Evaluation of boric acid baits for carpenter ants is lacking. Pest control operators have relied primarily on chemical techniques, in which success is dependent upon first locating and then destroying the entire colony. This is difficult to achieve because of the cryptic nesting habits of carpenter ants. Therefore, the development of an effective bait is needed.

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Previously, Reid and Klotz (1992) and Klotz and Reid (1993) reported on the oral toxicity of six toxicants to support development of delayed-action toxic baits for carpenter ants. Given the interest in boric acid as a bait toxicant and the lack of information about its oral toxicity to ants, as well as its potential for use against one of the more important structural pests, we report here the results of our toxicity experiments with the Florida carpenter ant, *Camponotus abdominalis floridanus* (Buckley).

Materials and Methods

Carpenter ants were collected in Alachua Co., FL, using the portable vacuum method of Akre et al. (1989). In the laboratory (25°C, ambient RH) the ants were provided with water but no food. One day post-collection, medium size worker ants were chosen from the colonies to achieve uniformity of size for the oral toxicity tests. These were then distributed, 10 each, into plastic Petri dishes (145 × 25 mm, Thomas Scientific) each supplied with a scintillation vial inside (7 ml, Kimble) plugged with cotton in which crystalline boric acid (Sigma Chemical Co., St. Louis, MO, 99% AI) was dissolved in a 10% (wt/vol) sucrose-deionized water solution to produce various molar concentrations (0.02 to 0.50) of boric acid. Ants fed immediately on the baits as evidenced by their abdominal distension within several hours after the tests were set up. Treatments and controls (sucrose-deionized water) were replicated on successive days and ants from a different colony were used for each replicate. The bait solutions were available continuously to the ants for the entire duration of the test. The ants were then placed in a climate-controlled chamber and held at 27°C and 80% RH. Daily observations on cumulative mortality were recorded for 7 days. Mortality data were corrected with Abbott's (1925) formula and analyzed by probit analysis (Raymond 1985) to determine the lethal time (LT_{50} and LT_{90}) values for each concentration of boric acid.

Results and Discussion

An essential element of an effective ant bait is that it exhibits a delayed action over at least a 10-fold range of dilutions (Stringer et al. 1964), to ensure that the toxicant can be thoroughly distributed throughout the colony before taking effect. Also, if the active ingredient (AI) becomes diluted among colony members, the resultant lower AI is still effective.

In our tests, boric acid exhibited this delayed toxicity (Table 1) when compared with the control. In the control (n = 90), mortality varied from 0.0 on day 1 to 11% on day 7. From 0.02 M to 0.04 M there was a marked reduction in the lethal time values indicating the minimum effective dose. At concentrations of boric acid of 0.04 M and above the LT_{50}s and LT_{90}s were fairly stable. At the maximum dose, 0.50 M, a faster mortality or lower LT_{50} and LT_{90} (95% CL) = 1.5 (1.2-1.7) and 4.2 (3.6-5.1) were obtained. In comparison to the boric acid baits developed in the past, these concentrations are lower (0.16 M = 1%) but effective. A low concentration of boric acid reduces the likelihood of avoidance.

Table 1. LT_{50}s and LT_{90}s of *C. abdominalis floridanus* workers fed boric acid bait.

Conc. molar (%)	LT_{50} (95% CL) days	LT_{90} (95% CL) days	Slope ± SE	No. ants	Chi Square	*P*
0.02 (0.13)	9.7 (8.1 -13.3)	27.1 (18.0 - 59.5)	2.87 (± 0.47)	110	7.3	0.06
0.04 (0.25)	4.5 (4.3 - 4.8)	7.9 (7.3 - 8.8)	5.26 (± 0.38)	110	9.7	0.08
0.06 (0.38)	5.1 (4.8 - 5.5)	11.0 (9.6 - 13.2)	3.90 (± 0.32)	110	7.5	0.19
0.08 (0.50)	4.2 (3.9 - 4.5)	9.1 (8.1 - 10.5)	3.80 (± 0.28)	110	10.8	0.06
0.10 (0.63)	3.1 (2.8 - 3.3)	7.0 (6.3 - 8.0)	3.54 (± 0.24)	110	8.3	0.08
0.15 (0.94)	3.3 (3.0 - 3.5)	7.4 (6.5 - 8.7)	3.62 (± 0.30)	70	7.1	0.21
0.20 (1.25)	2.8 (2.5 - 3.0)	8.3 (7.2 - 9.9)	2.71 (± 0.20)	110	7.5	0.18
0.25 (1.56)	2.5 (2.3 - 2.7)	5.6 (5.0 - 6.4)	3.62 (± 0.27)	80	3.2	0.67
0.30 (1.88)	3.1 (2.8 - 3.4)	9.3 (7.9 - 11.6)	2.67 (± 0.22)	90	0.7	0.98
0.35 (2.19)	2.4 (2.1 - 2.6)	5.9 (5.2 - 6.9)	3.21 (± 0.25)	80	10.0	0.08
0.50 (3.13)	1.5 (1.2 - 1.7)	4.2 (3.6 - 5.1)	2.83 (± 0.31)	60	2.4	0.67

Boric acid has several advantages as a bait toxicant for ants. First, it is soluble in water at the concentrations used. A sucrose-baited liquid toxicant exploits the natural feeding habits of sweet-eating ants, such as carpenter ants, whose major source of nutrition is honeydew (Pricer 1908, Gotwald 1968, Fowler and Roberts 1980, Hölldobler 1990). Secondly, boric acid has the added features of low risk to mammals with an oral median lethal dose (LD_{50}) for rats = 3160-4080 mg/kg (Quarles 1992) and minimal expense at the dosages that are effective against carpenter ants.

The mode of action of boric acid is unknown, but we observed one effect which may result from a disruption of water regulation. We noted that excretion of liquid feces was more frequent in the treated versus the control ants. This may cause the ants to imbibe more bait to counterbalance dehydration and consequently increase dosage. As the test progressed, the ants tended to remain on the cotton plugs of the boric acid bait vials for longer periods of time. The wide effective dosage range offers some flexibility in bait formulation, depending on the desired speed-of-kill. However, a quick kill reduces trophallaxis, so further testing will be necessary to determine the best dosage.

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