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Optimizing the Loading Level of Boric Acid in a Particle Bait: A Preliminary Study with *Periplaneta americana* (Blattodea: Blattidae)[1]

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Borates have a long history of use in the pest control industry and continue to be used extensively in managing a variety of insect pests in households and institutions (Sierras et al. 2018, J. Econ. Entomol. 111: 2772–2781). Appel (1990, J. Econ. Entomol. 83: 153–159) and Reierson (1995, Pp. 231–265, *In* Rust et al. [eds.], Understanding and Controlling the German Cockroach, Oxford Univ. Press, New York) acknowledged that boric acid insecticide baits changed how the pest control industry deals with the German cockroach, *Blattella germanica* (L.) (Blattodea: Ectobiidae); these baits remain as an important control tool. A major advantage in using boric acid baits is the very low probability of the development of physiological resistance to the toxicant (Cox 2004, J. Pestic. Reform 24: 10–15; Sierras et al. 2018).

Commercially formulated borate particle baits for cockroaches usually contain boric acid at concentrations between 5% and 10%. Pest control operators are typically instructed to apply half of the amount of particles when shifting to the use of a 10% boric acid bait from a 5% bait. Reasoning for this approach is based upon the assumption that an equivalent amount of toxicant is applied when the amount of particles is decreased by one-half. However, this assumption has not been adequately addressed. The study reported herein, thus, is a preliminary laboratory investigation to examine the validity of that assumption. This relationship, once known, will improve guidelines for cockroach control when using a boric acid scatter particle bait.

Test arenas used in the study were 58-l plastic Sterilite® containers (Sterilite Corp., Townsend, MA), each measuring 58.75 × 42.5 × 30.5 cm and fitted with screened lids that provided for air circulation. The inner sides of each arena were coated with a 1:1 mixture of petroleum jelly and mineral oil to prevent cockroach

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Table 1. *Periplaneta americana* mortality and consumption following exposure to boric acid particle baits.

Boric Acid Concentration (%)	Days to 100% Mortality	Bait Consumed (mg)
0 (untreated control)	NA*	46 ± 5.53
5	21	740 ± 23.05
10	14	620 ± 68.13
12	14	520 ± 32.00

*8% mortality at 21 days.

escape. Each arena contained a harborage site (22.5-cm-long cardboard tube, 6.25-cm diameter), two water sources (two 10-cm plastic test tubes filled with water and plugged with cotton balls), and a food source (petri dish containing 5 g of Purina® Rat Chow® [Nestle Purina, St. Louis, MO]). Water and food were replaced as needed.

Three commercially formulated baits with a boric acid concentration of either 5%, 10%, or 12% were tested. Two baits are available in the market—Niban (5%) (Nisus Corporation, Rockford, TN) and InTice[10] (10%) (Rockwell Labs, North Kansas City, MO). The 12% boric acid bait is not available in the market and manufactured at Nisus Corporation. Ten adult male American cockroaches, *Periplaneta americana* (L.) (Blattodea: Blattidae), obtained from a laboratory colony, were placed in each arena along with 5 g of the randomly assigned test bait. The untreated control received no bait. Each treatment was replicated five times with test arenas arranged in a room maintained at approximately 25°C. Lights were kept off during the testing period, except when mortality assessments and bait weight measurements were conducted at 1, 3, 5, 7, 10, 14, and 21 d posttreatment exposure. Cockroaches were considered dead when they did not move following prodding. Dead insects were removed from each arena at each of these sampling times. Mortality and bait consumption data were subjected to a general linear model analysis of variance followed by Tukey's pairwise comparison of treatment means using the IBM SPSS® statistical software (IBM, Armonk, NY).

Cockroach mortality recorded for the three boric acid bait treatments differed significantly from that recorded in the untreated control ($F = 3.718$; $df = 3$; $P < 0.03$), resulting in 98–100% mortality within 14–21 d after initial exposure (Table 1). The Tukey's pairwise comparison did not detect differences in mortality among the three boric acid test baits. Based on the sampling intervals conducted in this study, 100% mortality occurred within 14 d following exposure to either the 10% or 12% concentration, while the same level of mortality was observed at 21 d after exposure to the 5% bait (Table 1). Furthermore, the mean amounts of bait consumed for the duration of the test were 520 ± 32.00 mg for the 12% bait over 14 d, 620 ± 68.13 mg for the 10% bait over 14 d, 740 ± 23.05 mg for the 5% bait over 21 d, and 46 ± 5.53 mg for the control bait over 21 d (Table 1).

It is apparent from these results that the relationship of bait consumed and resulting mortality of *P. americana* is nonlinear and, thus, the assumption that only half as much of a 10% boric acid particle bait would yield the same level of cockroach control as a 5% particle bait. Furthermore, if consumption rates are the same for both baits, this would imply that the same level of efficacy would be achieved with the 10% bait in half the time required to achieve that level of mortality with the 5% bait. For example, if the 10% bait were 2× more efficacious than the 5% bait, one might expect that the 5% bait would require 28 d and the consumption of 1,240 mg of bait to result in 100% mortality. However, in this study, 100% mortality was observed in only 21 d following consumption of only 750 mg of the 5% bait. Hence, the 10% bait did not exhibit 2× the efficacy of the 5% bait, in terms of mortality achieved within a given time period. Based on these preliminary results, instruction and/or insulation of a direction of use label of a commercial bait to use only one-half the amount of bait when switching from a 5% to 10% boric acid concentration is not correct and can, in fact, lead to very unsatisfactory results.