In search of the 'sweet spot'

Borate-based liquid ant baits must have just the right amount of active ingredient to do the trick

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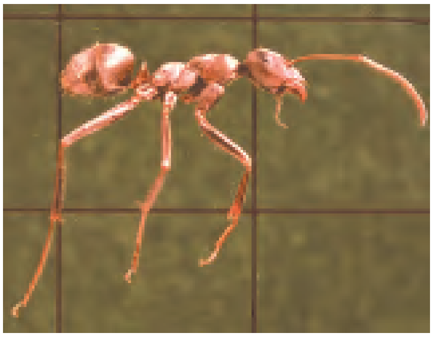
Borates are popular insecticides, as evidenced by the number of commercial ant baits that use them as active ingredients. Their popularity is due in large part to their low mammalian toxicity and favorable physical properties that have contributed to the registration of a large number of products. Many consider the products "reduced risk" in residential and agricultural settings. Another advantage is their solubility in water, which has become particularly important in liquid bait formulation for sweet-loving ants.

The challenge in developing liquid baits is two-fold:

1. Finding an attractive sugar-based solution that ants will readily consume.

2. Finding the optimal dose of borate for that solution so that it will not decrease its consumption, or interfere with ant recruitment and food exchange.

If the concentration of active ingredient is too high, the ants will die too quickly to maintain foraging trails to the bait solution. If it's too low, the toxicant will be diluted out of its effective range when it is passed from one ant to another. Thus, a bait's "sweet spot" is the range of concentrations of the active ingredient where a solution is readily consumed and exhibits delayed toxicity.



The Argentine ant loves its sweets.

PROOF OF IMPORTANCE

Two types of field tests illustrate the importance of finding this sweet spot.

Table 1. Consumption of seven baits in choice arenas by field colonies of Argentine ants. Six choice arenas were placed near ant trails for 24 hours. Averages followed by the same letter are not significantly different at P < 0.05.

Bait	Active Ingredient (%)	Avg. consumed (g)
A	borax (5.4)	0.64 a
B	borax (5.4)	0.05 b
C	borax (5.4)	0.29 b
D	boric acid (6.25)	0.06 b
E	boric acid (1)	0.21 b
honey	——	0.27 b
25% sucrose water	——	0.79 a

First, choice tests showed significant variation in Argentine ant response to commercial baits as measured by consumption (Table 1). Only one of the five borate baits tested, (A), was consumed as much as the 25% sucrose water.

Although several commercial baits have the same concentration of active ingredient, the differences in volume consumed can be attributed to the sugar content, type of sugar and other attractants in the baits. Viscosity is another possible factor.

Second, efficacy trials with one of the less-consumed baits (E) provided only 30% reduction in foraging ants (Figure 1, next page). Low consumption was probably the main reason for the marginal performance of this bait.

We have had much better results with 0.5% boric acid + 25% sucrose water in a large field trial, which provided about 80% reduction in the number of ants (Klotz et al. 1998). The greater efficacy of the 0.5% boric acid + 25% sucrose water bait compared to commercial bait (E), containing 1% boric acid, can be attributed to the lower palatability of the commercial bait and faster kill of workers. In most studies we have done, the most preferred bait has always been a 25% sucrose water solution.

For Argentine ants, the sweet spot is a 25% sucrose water solution containing 0.5 to 3.6% boric acid. This holds true for the other borates as well, because their toxicity is solely a function of their boron content (Klotz et al. 2000). The differences are minimal with anhydrous borax, boric acid and disodium octaborate tetrahydrate (DSOBTH) being 21.5, 17.5 and 21% boron by weight, respectively. Thus, a 5% solution of DSOBTH or anhydrous borax has about the same amount of boron as a 6% solution of boric acid.

The problem with baits containing 5% or greater borates is that ants consuming the bait are affected too quickly, compromising their ability to recruit and thereby distribute the toxicant to other members of the colony. There are even anecdotal reports of ants dying at the bait station. Clearly,

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Ant baits *from previous page*

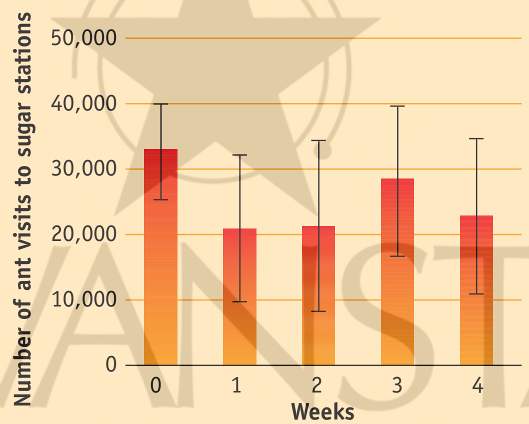

Figure 1. The efficacy of Bait E (see Table 1, previous page) in stations placed at five homes infested with Argentine ants. Ten stations containing 200 ml of bait were placed around the periphery of each home. Ant counts are based on the volume of sucrose water consumed from 20 monitoring stations per residence. Bait stations were replaced weekly with fresh stations. Error bars are ± one standard deviation of the five replicates.

this kind of response does not exploit ants' social biology, which can be used to spread the toxicant to its fullest extent. That said, a fast-acting bait may have its place — eliminating ants quickly from an indoor incursion, for example.

In most cases, however, the colony dynamics of many pest ants precludes the use of fast-acting baits. To penetrate the diffuse colonies of Argentine ants, pharaoh ants, pavement ants, ghost ants, white-footed ants and odorous house ants with a toxicant requires a slow-acting bait. A fast-acting bait will only affect nearby nests, not the network.

Dilute borate baits containing 0.5% to 1.0% boric acid or borate salts can be highly effective at penetrating the colony, but they must be administered over an extended period of time. This complicates the treatment, because the bait is subject to evaporative concentration and may require periodic refilling.

In the field study cited earlier, a reduction of 80% was attained after nine weeks of continuous treatment with a bait containing just 0.5% boric acid and 25% sucrose (Klotz et al. 1998).

Bait stations carrying dilute borate solutions should be large enough to hold at least 500 ml of bait, designed to minimize evaporation, and placed out of the sun. Because of the low mammalian toxicity of borate baits, stations that allow users to refill them may be an option.

THE TROPHALLAXIS FACTOR

One problem with dilute borate baits is the tendency for dilution of the toxicant during food exchange between ants, known as trophallaxis. Markin (1970) showed that a single worker will feed between four and 12 other workers. The bait is diluted during this food sharing, and may become diluted to the point of ineffectiveness. This is a concern for borate baits because the concentration range of efficacy is 0.5%

to 3.7%, or a 7-fold span. This is a relatively narrow range of efficacy when compared to other insecticides such as imidacloprid (13-fold) and thiamethoxam (15-fold) (Rust et al. 2004).

As a consequence, there is less room for error when formulating baits with boric acid. If they are too dilute, they are nontoxic and if they are too concentrated, they kill too quickly, reducing penetration into the colony.

Boron-containing ant baits are popular, but their efficacy is highly variable because of attractant quality, boron concentration and effectiveness of the delivery station. The palatability of borate baits can be dramatically affected by additives and preservatives added to commercial baits. Typically, the fewer additives added to borate baits, the better the bait is accepted. Formulators need to consider these issues when designing boron-based ant baits.

The effectiveness of borate products must not cause users to be complacent about the need for safely handling pesticides, including borates. Adverse effects are extremely unlikely, but skin irritation and nausea, vomiting and stomach pain may occur with high exposure relative to exposures from normal use. Borates are among the relatively few chemicals that are more toxic to children than to adults (US EPA, 1999). Normal use does not present special issues, but storage of unused product must guard against accidental exposure.

What are harmful exposures? Single exposures by mouth or skin contact rarely produce harm. Teaspoons' full for several weeks have been associated with skin, kidneys and the nervous system. These concerns are easily avoided if you *follow the label* and respect chemical's potential for adverse effects. PC

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