

**Boric Acids Activity as a Possible Repellant to the Argentine Ant****Sean Pelham**

**Abstract** With a greater emphasis being placed on organic farming as a means of production, more focus needs to be on chemicals such as boric acid and their potential as organic pesticides. This work aims to find the concentration at which boric acid may act as a repellant to Argentine Ants, ultimately determining how boric acid baits can be used as a means of ant population control, rather than repellants. Two separate studies in Napa used different approaches to analyze ant repellency. The first involved a series of six bait tubes each containing concentrations of boric acid from 0.0 to 1.0% in 25% sucrose solution, placed under their own vines, to ensure activity from individual colonies, and testing the general ant repellency of specific concentrations of boric acid. In the second study, all six individual concentrations were tied together and wrapped around the vine. Each “belt” had one colony that could choose from the six different boric acid concentrations, gauging the ants’ preference for one concentration of boric acid. The results of first portion of the study show that generally, an increase in the concentration of boric acid leads to fewer ant visits for the bait stations with high boric acid concentration, which means that ants could ultimately be avoiding toxic baits entirely at concentrations of 0.5 and higher.

**Introduction**

Although organic farming has grown in popularity in the eyes of the public, few people realize that it recognizes the use of certain chemicals as “organic pesticides”. Amongst these pesticides, boric acid has been shown to be particularly effective in the control of ants, which take care of phloem feeding insect pests such as scales and mealybugs. The ants form mutually beneficial symbiotic relationships with such insects, harvesting the honeydew that these pests create as a waste product, all while protecting the pests from natural predators and parasitoids (Siebert, 1992). These parasitoids would have otherwise been helpful to agriculturists as they implant their eggs into their pest host, with the developing larvae killing the host once it has reached maturity (Völkl, 1994). With the ant population reduced however, farmers can successfully implement biological control measures to keep pest populations below a certain economic threshold.

The Argentine ant is an invasive species of ant that is found all over the state of California, and has caused various problems in urban, agricultural, as well as natural ecosystems. It can easily establish itself within disturbed environments (such as agricultural fields), and can quickly adapt to new ones in a relatively short period of time. For Napa California, the control of these insects is particularly important, as the Argentine ant tends and protects a persistent pest in vineyards, the mealybug (Vega and Rust, 2001). As a phloem-feeding insect, the honeydew it exuded by the mealybug as a byproduct of its feeding has the tendency to cover the vine and allow an adequate food source and substrate upon which fungi may thrive, rendering a particular bunch useless for harvest (Kent Daane). This honeydew also attracts the Argentine Ant.

For those organic vineyards that have such problems and resort to organic pesticides such as boric acid, farmers need to know whether or not boric acid itself is actually effective in reducing Argentine ant populations, or is ultimately driving them away to feed on the honeydew provided by certain pest insects. When boric acid is applied, it is generally done so mixed in with sugar water. If the ants can distinguish between the taste of just sugar water and sugar water with boric acid, they may bypass bait stations entirely, rendering the baits useless. In this case, the ants opt to continue harvesting honeydew from the existing mealybugs or scales. Thus, an ideal situation would be for the boric acid baits to have a high enough concentration as to cause mortality in ant

populations, but not so much that they can distinguish differences in taste between an effective concentration and just sugar water.

The primary issue I plan to explore is to find the concentration at which boric acid in sugar water does not repel ants. Based upon previous experience, the suggested concentration of 0.5% boric acid in 25% sucrose solution (Klotz, 2000) is one that ultimately repels ants, preventing boric acid baits from being truly effective. In investigating this I conducted two tests. The first portion was a trial in general ant repellency, while the second tests for feeding preference within ants among different concentrations of boric acid.

Work in this area has been conducted before (Klotz, 1998; Klotz et al, 2000), but the extent to which I wish to explore the issue is slightly larger. Previous studies were somewhat limited in terms of their sample size, and with higher thresholds of boric acid concentrations. For instance, the lowest concentration within Klotz's study was 0.5% boric acid in 25% sucrose solution, and he ultimately determined that this concentration was adequate for attracting and killing Argentine ants. I believe that lower concentrations may prove to be even more effective at attracting ants, and that suggested concentrations of 0.5 to 1.0% may be too high. In this study, a lower range of boric acid concentrations were used, with more baits released into the field.

## **Methods**

The study was conducted in south Napa California at Sutter Home Vineyards. There were two major portions to the study. The first involved a general ant repellency test, while the second involved a basic ant preference test. Both essentially investigated the same question: at what concentration does boric acid act as a repellent to Argentine Ants? But, each portion of the experiment differed in how they generate their respective results. The general repellency test was split up into 30 experimental blocks. Each block consisted of six different concentrations of boric acid (0.0, 0.1, 0.2, 0.3, 0.5, and 1.0%) in 25% sucrose solution in 50ml tubes. Because I am only concerned with measuring the difference from the beginning to the end of when the ants feed, the actual amount of liquid within each tube can vary. Each tube was placed 5 vines from one another (five vines equals roughly twenty feet), while each experimental block was spaced twenty

vines down from the next experimental block (roughly eighty feet) in a given row. There were three blocks per row; with ten rows being used altogether. There were five rows in between those rows within which the experimental blocks were placed, making this distance roughly forty feet. Thus, each tube for each block within each row had to be spaced far apart from one another so as to assume that only one colony is tending to one bait tube. This portion of the overall experiment was conducted in three phases. The first phase involved the release of 180 bait tubes with just 25% sucrose solution in each. The purpose was to acquaint the ants with the location of the bait tubes, so that they would be aware of their locations once the boric acid tubes replaced them, as well as to get an initial gauge of ant activity. The second phase of the general repellency test involved the release of the boric acid tubes themselves. Each plot had one of the six different concentrations, and the ants were allowed to feed on them for a period of two days. The third phase began immediately after the second phase, with the release of 25% sucrose solution once again in order to get another measurement of relative ant activity. This portion of the repellency test only lasted one day. At all stages of the experiment inaccessible bait tubes with 25% sucrose solution were placed within the blocks in order to take into account liquid lost through evaporation.

For the second portion of the experiment, the ant preference test, a separate area of the vineyard was chosen within which to conduct testing (i.e. this was not done within the same plot as the repellency test). Again, the same six concentrations of boric acid were used, and again the bait placement was randomized to eliminate preference based upon order. The six tubes were taped together, and the resulting “belt” was then wrapped around a vine. In this experiment, I assume that colonies can access only one belt. Thus I can establish which of the concentrations ants prefer. Again, evaporation tubes were placed at each of the belt sites, in order to take into account the effects of evaporation.

For both portions of the study I conducted a standard ANOVA test, plotting a regression for the general ant repellency test, in order to find at which concentration it appears that boric acid acts as a repellent.

## Results

For the general repellency portion of the experiment there appeared to be a general downward trend of ant activity as the concentration of the boric acid in the bait station was increased. Figure 1 illustrates this trend. The middle of each diamond represents the mean amount removed from that particular concentration of boric acid, while the top and bottom of the diamond represents the standard error. When a Dunnett test was run using 0.0% as the control, amount removed from concentrations of 0.2, 0.5, and 1.0% boric acid proved to be significantly different. The one-way analysis of the preference test has an  $r^2$  value of 0.23, and a p-value of less than 0.001

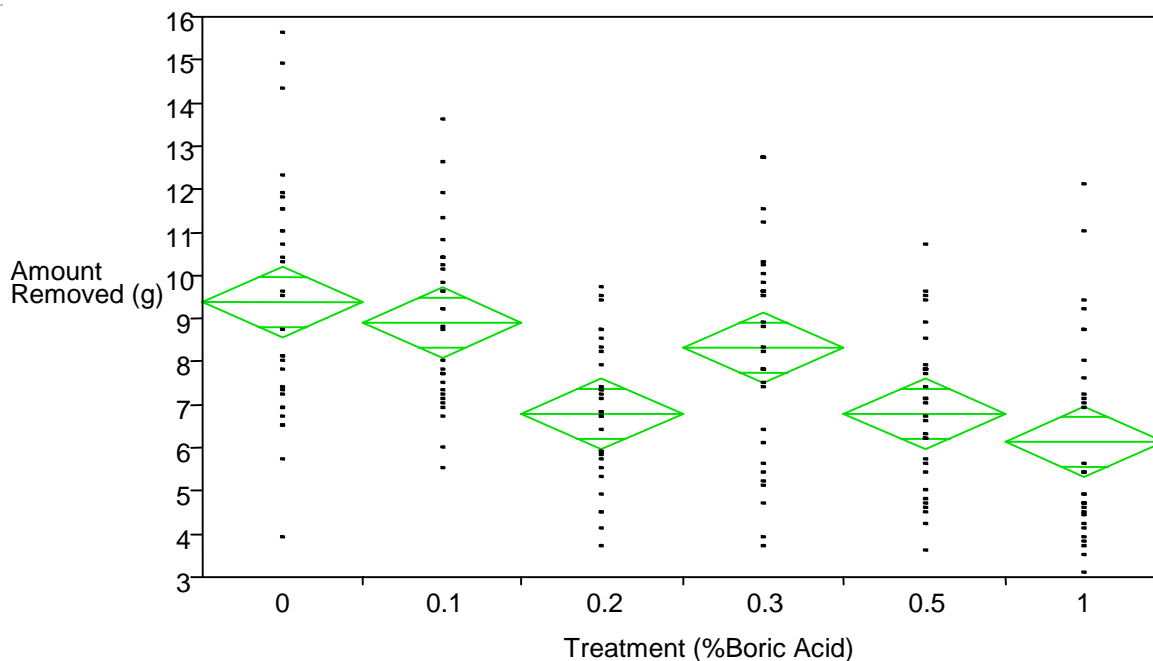


Figure 1. Amount boric acid/sucrose solution moved from baits in general repellency test (including liquid lost from evaporation)

Figure 2 provides a clearer picture to the relationship between increasing concentration of boric acid and amount removed. In this instance, a regression analysis was run using a polynomial fit degree of 2.

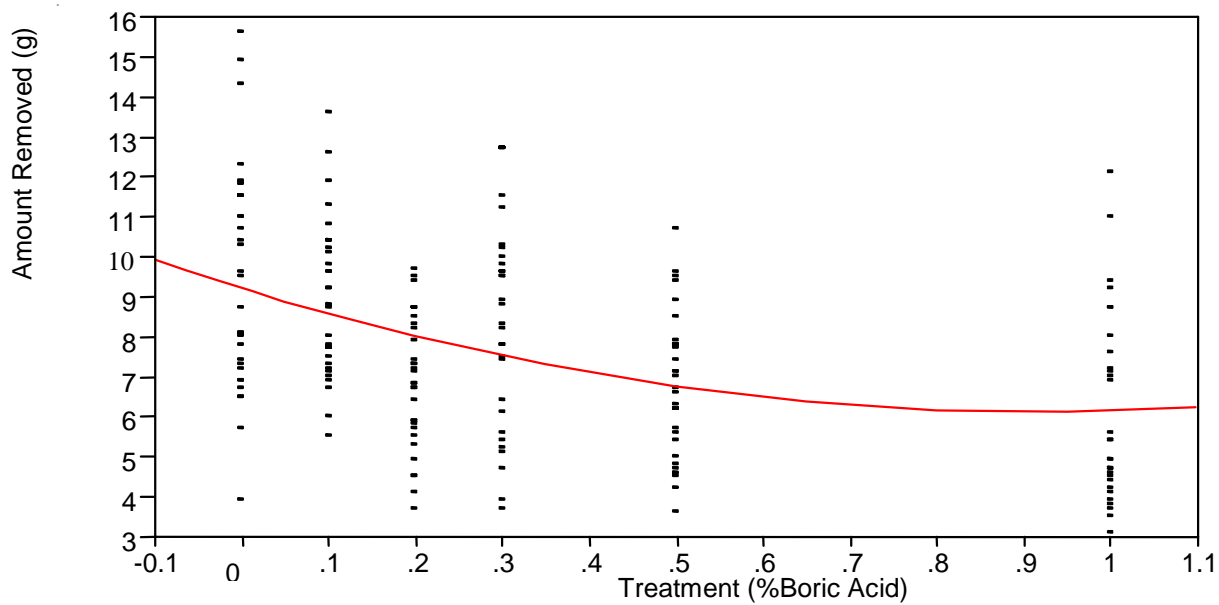


Figure 2. Linear regression of ant preference test

Fig. 3 shows the one-way analysis of the ant preference test. Shown are the means for each of the amounts removed for each concentration, as well as the standard deviations from the means

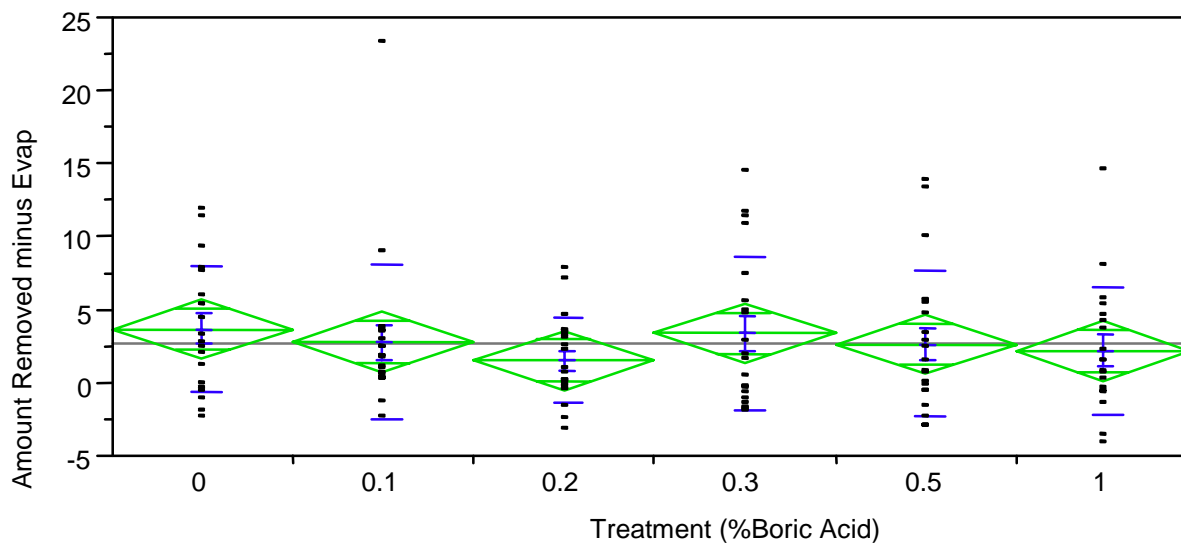


Figure 3. Amount boric acid/sucrose solution removed considering amount removed due to evaporation during the preference portion of the experiment.

This analysis has a p-value of 0.7162, with an  $r^2$  value of 0.025, indicating that the concentrations did not prove to be significantly different from one another.

## **Discussion**

For the general repellency portion of the experiment, there appears to be a definite correlation between concentration and relative amounts of ant activity. As the concentration was raised from 0.0%, there appears to be a drop off in the activity of those bait stations containing subsequent concentrations. The relationship between amount of liquid removed and boric acid concentration was relatively significant, with an  $r^2$  value of 0.23. When running a regression with the current results, it appears that ants can tell the difference between just plain sugar water and sugar water with concentrations of boric acid 0.5% and higher. Unfortunately, the results still do not provide a clear picture as to when the distinction is made. If they can discern low enough concentrations, further studies need to be conducted in order to see if these concentrations would even be effective in reducing Argentine ant populations.

In the end it is more about striking a balance between what would be considered a toxic concentration and what would appeal to the ants. It is not simply a matter of keeping the concentration of boric acid high, however, in order to more effectively eliminate the ants. Through trophylaxis ants can ingest some of the bait and then orally excrete the bait to other members of their colony. Thus it is essential for the ants to be drawn to the bait stations in order to frequent them and eventually spread more of the bait around the colony. This means keeping the concentrations low enough such that ants will frequent the bait stations, yet high enough in order to eventually lead to a toxicity effect in those ants that have fed from the bait tubes.

For the preference portion of the experiment, it appears the weather did not suit the activity that I was hoping to see at each of the belt sites. Because it rained for about three days straight after the belts were in the field, ant activity was low in general over the next few days. When the belts were retrieved after a period of ten days, the average amount

removed from the belts was only roughly 3-4 grams per tube, once the evaporation tubes were taken into consideration. Thus, though the tubes were out there for a much longer period than what had been attempted in an earlier investigation, the activity was still too low overall to generate a clear discrepancy between different concentrations. In the future the belts would have to be placed during the peak months of ant activity, such as July or August. Because during the hotter months baits tend to disappear much more quickly than one would expect, this portion of the study may also be conducted within the laboratory, with collections of several colonies, each one subjected to its own boric acid bait belt. Advantages to this change would be control over the temperature and humidity, control over colony sizes, as well as food availability.

### Acknowledgements

I would like to thank Kent Daane and Erik Nelson for all of their helpful insight for creating and following through with this project. I would also like to thank Mia Orsini, Elaine Shapland, Helen Beeson, and William Robbins for their contributions during data collection.

### References

- Klotz J., L. Greenberg, and E. C. Venn. 1998. Liquid boric acid bait for control of the Argentine ant (Hymenoptera: Formicidae). *Journal of Economic Entomology* **91**:910-914.
- Klotz J. H., L. Greenberg, C. Amrhein, and M. K. Rust. 2000. Toxicity and repellency of borate-sucrose water baits to Argentine ants (Hymenoptera: Formicidae). *Journal of Economic Entomology* **93**:1256-1258.
- Seibert T. F. 1992. Mutualistic Interactions of the Aphid *Lachnus allgheniensis* (Homoptera: Aphididae) and its Tending Ant *Formica obscuripes* (Hymenoptera: Formicidae). *Annals of the Entomological Society of America* **85**:173-178.
- Vega S. J., M. K. Rust. 2001. The Argentine Ant - A Significant Invasive Species in Agricultural, Urban, and Natural Environments. *Sociobiology* **37**:3-25.
- Volkl W., M. Mackauer. 1993. Interactions Between Ants Attending *Aphis fabae* ssp. *cirsiiacanthoidis* on Thistles and Foraging Parasitoid Wasps. *Journal of Insect Behavior* **6**:301-312.