I. Introduction

 Argentine ant (*Linepithema humile*) infestations are the number one reason homeowners call Pest Management Professionals (PMPs) in southern CA. Ant populations increase through late spring and early summer and homeowner complaints increase at the same time. For the past 29 years, our Urban Entomology Ant Program at UCR has conducted trials around homes of local residents who have infestations of the Argentine ant. Our primary objective has been to compare the efficacy of different insecticides and strategies in reducing the ant numbers around houses. Some of the variables tested include: different active ingredients; different formulations of the insecticide; and different application techniques. Most of the active ingredients are formulations of pyrethroids, fipronil, or botanicals. Formulations of pesticides that we have tested include sprays, granules, and baits.

Besides these efficacy trials around homes, we have also been measuring the insecticide runoff of pyrethroids and fipronil from treated structures for the past decade. Our overall goal has been to find treatments that are effective against Argentine ants while minimizing the runoff of these treatments into the street and storm water systems. To quantify the amount of pesticide in the water runoff and compare treatments, a wall on a concrete slab was constructed at the Agricultural Operations at UC Riverside to simulate conditions found around homes. The concrete wall and pad let us replicate and compare insecticide runoff when different band widths, concentrations, or formulations of insecticides are applied. It also permits us to control the effects of rain events. All the pesticide samples are analyzed in Dr. Jay Gan’s laboratory in Environmental Science at UC Riverside.

The Office of Pesticide Programs of the US EPA has published invertebrate aquatic life benchmarks for pesticides (US EPA 2017). They represent the upper boundaries for either acute or chronic toxicity. For fipronil the acute benchmark is 0.11 µg/L, or 0.11 ppb = 110 ppt, and the chronic benchmark is 0.011 µg/L, or 11 ppt. For bifenthrin the respective values for acute and chronic toxicity are 800 and 1.3 ppt. Ideally, our runoff values from houses should be lower than both measures.
II. General Methods

A. Constructed Wall and Pad

One of the major problems in testing insecticide treatments outdoors around structures is the amount of variability between homes. Differences in the square footage treated, the landscape around the foundation of the structure, and irrigation patterns used by the homeowner make direct comparisons between homes complicated. For a previous contract we had constructed a wall and concrete pad to simulate a wall/driveway interface to help minimize this variability (Greenberg and Rust 2013). The wall is 3 ft high and 36 ft wide (Fig. 1). The concrete pad on each side of the wall is 10 ft wide by 36 ft long. There are 12 3-ft wide segments on each side of the wall (east and west sides) for a total of 24 segments that can be used for treatments. Latex paint was applied to the wall. Strips of metal flashing separate each of the segments so that runoff can be collected for each individual segment. The flashing narrows down at 10 ft from the wall to a spout where water samples are collected (Fig. 2). During a treatment, two large pieces of plywood placed at each end of the segment ensure that sprays do not contaminate the other segments. To apply different band widths of insecticides to the wall and concrete pad, pieces of paper are taped to the wall and concrete pad (Fig. 3). To generate runoff, irrigation sprinklers on both sides of the wall are adjusted to give an equal distribution of simulated rain on both the wall and pad. In this manner, the treated segments can be exposed to specific amounts of simulated rainfall. After treatment, irrigation is initiated and all samples are collected simultaneously. It takes approximately 9 minutes to collect the 12 treatments from one side of the wall during which about 0.17 inches of rainfall occurs. These rainfall totals simulate a light rain likely to occur during the dry season in southern California when bifenthrin would be applied for ant control.

B. Ant Efficacy - Houses

Residents from Riverside and adjacent communities were recruited as cooperators in our summer ant program. The homes were selected based on the number of ants present and the slope of the driveway to the street. A gentle slope facilitated the collection of water samples. The homeowners permitted us to monitor and treat the ant infestations around their homes. In addition, they allowed us to wash the driveway when water samples were collected.

The efficacy of treatments was calculated from a reduction in ant (*L. humile*) foraging based on adjusted weight loss from monitoring vials of sugar water before and after treatment, rather than based on numbers of ants counted or trapped. Ten 15-ml polypropylene tubes (Falcon® screw cap vials) filled with 13 ml of 25% (wt/vol) sucrose were placed around the foundation of each house (with 2 or 3 vials at each side of the house). All vials were covered with an inverted
clay 15.24 cm flower pot to prevent sprinklers from diluting the sugar water and animals from disturbing them (Fig. 4). Control vials (n=5) were simultaneously run (free of ants) to correct for evaporation of water during each monitoring period. After 24 hours, the vials were sealed and returned to the laboratory and weighed. Loss of liquid (i.e., weight) from the tubes was corrected for evaporation of water. The adjusted weight loss value made it possible to estimate the number of ant visits per station.

There is a direct relationship between amount of sugar water taken, ant visits, and the number of ants in the area. Lower numbers of visits represent lower overall ant numbers. The number of ant visits is calculated by dividing the consumption (g) by 0.0003 g/visit, a single Argentine ant consuming 0.0003 g of sucrose water per visit (Reierson et al. 1998). One advantage of such monitoring is that it reflects long-term foraging (i.e., 24 hr) and does not depend on singular momentary observations that may vary greatly with time of day. Only residences with significant ant feeding at 8 or more stations of each group of 10 were used in the studies. An average of at least 6 ml taken per vial was considered significant. Unless otherwise stated, we used 5 homes per treatment. These same houses were used for water runoff analysis.

In 2014, spray treatments around houses were done with a 1-gal B&G tank backpack sprayer using a Multeejet C&C 4-way Tip (B&G model #5800-CC) that also allowed for a fine spray pattern and pin stream applications. The homes were monitored 1 week before and 1, 2, 4, and up to 8 weeks after the treatment.

C. Water Runoff from Houses

Water samples were collected from each of the treated homes to determine the amount of pesticide runoff. Water samples were collected on the driveway 20 ft from the garage by setting up a water dam across the driveway (Fig. 5). The dam consisted of two segments connected with a hinge that allowed the dam to open and cover most of a typical driveway. A garden hose was used to flush water down the driveway from the garage towards the dam where a 1 L sample was collected (Fig. 6). The volume of water used was recorded with a Rain Wave™ gauge attached to the hose.
III. 2014 Summer Studies

Our main objective in this study was to determine how the bandwidth of the insecticides applied around structures affected both the control of ant populations and the amount of pesticide runoff.

PMPs typically apply bands of insecticide around the house foundation to prevent ants from entering the structures. Historically, these bands have been as broad as 10 ft. away from the foundation. In recent years, the band applications of bifenthrin at the house foundation are frequently applied 2 ft up and 3 ft out from the foundation. The effect of different bandwidths on runoff is not well understood, although we have published previously on this topic (Greenberg et al. 2010, 2014, 2017). Questions concerning application techniques remain. How does insecticide runoff compare between different band widths? And how does the ant efficacy compare?

PMPs have limited abilities to alter the amounts of pesticides being applied around structures. They can alter the concentration of the insecticide or the width of the band depending upon the label recommendations. It is much more difficult to accurately alter the rate at which they apply the sprays. Most companies don’t have pressure regulators on their equipment. With this in mind, two studies were conducted in 2014. The wall and concrete pad was used for testing various band widths of bifenthrin sprays, while the house trials included both bifenthrin and fipronil sprays.

A. Trials on the Constructed Wall and Concrete Pad

A.1 Hypothesis Two different sets of null hypotheses were tested. One hypothesis was tested on the 12 segments on the east wall and the second hypothesis was tested on the 12 segments of the west wall.

Null Hypothesis 1 (East Side of Wall). There are no differences in bifenthrin runoff from each wall segment when different band width applications are applied at the same rate per unit area (0.00235 g active ingredient (AI)/ft²; Table 1)

Null Hypothesis 2 (West Side of Wall). There are no differences in bifenthrin runoff from each wall segment when different band width applications are applied at different rates per unit area to give the same total amount of bifenthrin (0.0352 g AI per wall segment; Table 2).
A.2 Specific Methods – Wall and Pad

Before the 2014 applications, both sides of the wall and pads were scrubbed with detergent and thoroughly washed. The day after cleaning the wall we turned on the water sprinklers and collected water samples for a pretreatment analysis. We treated both east and west sides of the wall with bifenthrin (Talstar® P) to look at the effect of application rates and different band widths on its runoff. For both sides we chose three different bandwidths to apply to the wall and contiguous pad. We used a wide band application of bifenthrin (2 ft up x 3 ft out from the wall), a narrower band (1 ft up x 1 ft out), and a very narrow band (2 in up x 2 in out). Each of the 3 treatments had 4 replicates on each side of the wall, for a total of 24 treated segments. On each side of the wall, a band width treatment was randomly assigned to each segment. The two sides of the wall were treated approximately 2 weeks apart. Irrigation runoff was collected 1 day post treatment.

On the east side of the wall (Table 1) bifenthrin was applied at the label rate of 1 oz of Talstar® P per gallon finished spray solution (0.062% bifenthrin AI), applied per 1,000 ft². This criterion meant that the wide band (5 ft x 3 ft, or 15 ft²) would have the greatest total amount of AI applied per segment because it covers the largest area of the 3 treatments. The narrowest band (4 in x 3 ft, or 1 ft²) would have the smallest total amount of AI applied because it covered the smallest area, and the 2 x 3 ft band (6 ft²) would be intermediate in total AI applied. We kept the label rate per unit area constant by varying the spray time. The narrowest band had the shortest spray time, while the wide band had the longest spray time. Each band received 0.00235 g of AI per sq ft.

On the west side of the wall (Table 2) bifenthrin was applied to keep the total amount of AI applied per wall segment constant. To keep the AI constant for each segment we varied both the time of the spray application and the concentration of the bifenthrin solution. The wide band was sprayed with the lowest concentration of bifenthrin with the longest spray time. The narrowest band was sprayed with the highest concentration and the shortest spray time. Using spray concentrations ranging from 0.062 – 0.16 % bifenthrin, each band received a total mass of 0.0352 g of bifenthrin.

A.3 Results and Discussion 2014 - Wall and Pad

For the east side of the wall the pretreatment bifenthrin concentration was 11.0 ± 1.6 ppt (mean ± SE). On the west side of the wall it was 17.6 ± 2.6 ppt (mean ± SE). These values are higher than US EPA aquatic invertebrate chronic benchmark for bifenthrin (1.3 ppt; US EPA 2017), suggesting that low levels of bifenthrin persist in the environment at levels that could
potentially be toxic to aquatic organisms. These surfaces were thoroughly cleaned and had not received any bifenthrin treatments for approximately one year.

There were no significant differences (N=4, \( P > 0.05 \), ANOVA) in the concentration of bifenthrin in the irrigation runoff from treatments on the east side of the wall, where: 1) the band width varied, 2) the bifenthrin concentration was the same for all treatments, 3) the application rate per unit area was kept constant (0.00235 g/ ft\(^2\)), but 4) the total bifenthrin AI applied was less in the narrower band treatments (Fig 7A). The mean runoff for all treatments varied from 67,000 ppt (2 ft x 3 ft wide band application) to 151,000 ppt (2 in x 2 in band). Therefore, hypothesis 1 was not rejected; there do not appear to be any differences in bifenthrin runoff regardless of band width when 0.062% bifenthrin is applied (highest labeled rate of Talstar® P). The results from these trials suggest that narrower band widths do not mitigate bifenthrin runoff. This may be specific to the low irrigation totals, short irrigation times, and sample collection time used in this study. Perhaps higher irrigation totals (or heavy rainfall) or additional irrigation days would generate differences in runoff. However, under the auspices of this contract, we were not able to evaluate additional irrigation practices or timings.

In the trials on the west side of the wall, where: 1) the band width varied, 2) the bifenthrin concentration increased with decreasing band width, 3) the application rate per unit area increased with decreasing band width, but 4) the total bifenthrin AI applied was constant for each wall segment differing band widths, there were significant differences in runoff among the treatments. In these trials, runoff means ranged from 82,000 ppt (2 in x 2 in very narrow band application) to 323,000 ppt (2 ft x 3 ft wide band application) (Fig. 7B). The very narrow band (2 in x 2 in) application had significantly lower concentrations of bifenthrin in the irrigation runoff water than the wider band treatments (1 ft by 1 ft or 2 ft by 3 ft band applications) (\( P < 0.05 \), Tukey HSD test). Therefore, hypothesis 2 was rejected; band width does make a difference in runoff when very concentrated solutions of bifenthrin are applied to concrete surfaces. This result seems to contradict the results from the east wall. Perhaps the limited amount of irrigation water (up to \( \approx 0.17 \) in rain in 8.6 min of irrigation) contacting the narrow band cannot fully access the higher bifenthrin concentration (2.5x the labeled rate of Talstar® P) due to sorption on the concrete or other factors. Again, higher irrigation totals, more irrigation time, or additional irrigation days would have allowed more runoff with the very narrow band application.

Our results suggest that the very narrow band application does not mitigate bifenthrin runoff with labeled concentrations of bifenthrin (i.e., based on Talstar® P label) if rain or irrigation is applied shortly after application. However, even if the very narrow band does reduce runoff as
observed on the west wall (2.5x labeled rate), the runoff will be above US EPA benchmarks in the runoff water and could contribute to aquatic toxicity in surface waters. Other mitigation measures may be more appropriate than narrow banded applications (e.g., no applications to garage door/driveway areas; Greenberg and Rust 2017).

**B. House Treatments 2014**

The two objectives of the 2014 field trials were to determine the impact of the different band widths and buffer zones of bifenthrin and fipronil on ant efficacy and the amount of pesticide runoff. Each treatment consisted of 5 homes.

**B.1 Specific Methods 2014**

**a) Bifenthrin.** Bifenthrin was applied at the label rate of 1 oz of Talstar® P per gallon finished spray solution (0.062% bifenthrin Al), applied per 1,000 ft². The bifenthrin treatments consisted of: a) the standard 2 ft up x 3 ft out band at the building foundation plus a crack and crevice treatment along the lawn-driveway edge of the driveway; (b) the same standard treatment minus the crack and crevice application; and c) a 2 in x 2 in very narrow band around the house foundation. Bifenthrin was not applied at the garage door area in any of the treatments.

**b) Fipronil.** Fipronil was applied at the label rate of 0.8 oz of Termidor®SC per gallon finished spray solution (0.06% fipronil Al), applied per 1,000 ft². The fipronil treatments were applied all around the house perimeter, with no treatments on the driveway. The treatments were either pin stream applications (1 in up and 1 in out from the foundation) or 6 in up and 6 in out from the foundation. However, the afternoon after the morning pin stream application an unexpected monsoonal storm flooded streets in Riverside and all of the treated houses. We decided to continue collecting data from those houses, but also treated another 10 houses with a pin stream application. In all, the pin stream application was done at 10 houses, whereas 5 houses each were treated with the pin stream followed by rain and the 6 in x 6 in treatments.

**B.2 Results and Discussion 2014**

**B.2.1 House Runoff**

**a) Bifenthrin.** Fig. 8 shows runoff of bifenthrin at days 1 and 28 post-treatment. At day 1 and 28 the very narrow band (2 in x 2 in) had numerically the least runoff, although the variability in the amounts of bifenthrin detected was too high to show significant differences. On day 1 (but not day 28) the treatment including the crack and crevice along the driveway had the highest runoff. In general, the very narrow band treatments were trending lower than the others.

The means of house runoff for day 1 and day 28 are mostly less than 1,000 ppt (Fig. 8), which is much lower than the values obtained from the constructed wall (Fig. 7; values closer to 100,000...
ppt). Higher volumes of water are needed to collect runoff from homes, due to driveway length, width, cracks, and sorption, resulting in lower detected concentrations of bifenthrin. And because there were no applications to the garage door area, the detected concentrations were generally below US EPA acute (but not chronic) benchmarks (Fig. 8). In these house trials, no pretreatment measurements were taken due to resource. However, pretreatment results from our 2014 constructed trial suggest that the chronic concentrations of bifenthrin can persist in the environment (although the day 28 concentrations are likely higher than the background environmental concentrations suggesting that bifenthrin will continue to degrade or lessen over time).

b) Fipronil. Fig. 9 shows fipronil runoff from the three groups of houses at day 1 post-treatment. The results are not quite significant (AOV, \( P = 0.07 \)), although the narrow band on houses that received rain that afternoon had the highest runoff and the 6 x 6 in band had the least. It is possible that the rain (1.4 in; CIMIS 2017) washed off some of the fipronil from the sides of the house to the driveway. However, most of the fipronil runoff concentrations were below the US EPA acute invertebrate aquatic benchmark (110 ppt) suggesting not applying fipronil the driveway area could be a mitigation measure to reduce aquatic invertebrate exposure to fipronil.

B.2.2 Efficacy of Ant Treatments

a) Ant Efficacy with Bifenthrin. Fig. 10 shows the efficacy of the three bifenthrin treatments in reducing ant numbers. The standard treatment of the 2x3 ft band with a crack and crevice treatment along the edge of the driveway had the greatest percent ant reductions on weeks 1 and 2; the pin stream application had good results at weeks 1 and 4. The result with the pin stream application is surprising because PMPs and researchers have always assumed that wide bands of bifenthrin are necessary for control. Additional experiments are needed to see whether the narrow band use of bifenthrin is a viable option, but results from these trials suggest the narrow band may be effective in controlling ants while reducing runoff (Fig. 8).

b) Ant Efficacy with Fipronil. Fig. 11 shows the efficacy of the three fipronil treatments in reducing ant numbers. At week 1, there was little difference in ant reductions among the 3 treatments. However, after week 1, there was little ant control. These results indicate that the pin stream can be as effective as wide band applications in controlling ants and week 1, but for residual control, some type of treatment to the driveway area is necessary (Greenberg et al. 2010, Greenberg et al. 2017, 2015 house results in this report (Fig. 12)).
IV. 2015 Summer House Study

In the summer of 2015 the main objective was to compare the efficacy and the amount of pesticide runoff of three different band widths of fipronil applied around homes in Riverside. The cracks in driveways serve as a potential avenue for ants to invade structures and as entrances to potential nest sites. In previous studies the highest efficacy was achieved when treatments were applied on and around driveways (Greenberg et al. 2010).

We also wanted to know what the fipronil runoff would be when a pin stream was applied at the garage door while using wider bands around the rest of the house. These results could be compared with the 2014 fipronil trials where no treatments were applied to the driveway.

A. Specific Methods for 2015

We treated 21 homes with Termidor® SC. There were 3 different treatments (Table 3). Applications were made with the with the standard fipronil treatment (labeled rate; 2 quarts 0.06% Termidor® SC per 160 linear feet) or with half this amount (pin stream and reduced swath applications). The different fipronil treatments were applied around the entire house perimeter (foundation); however, in all 3 treatments the pin stream treatment was applied to the driveways (Table 3). All treatments were applied with a 1-gal B&G tank sprayer equipped with a 4-Way Multeejet Tip (B&G model #5800-CC). We attached a pressure gauge (1535 Gauge 0-60 B&G Red) to keep the tank pressure at 20 psi so that we could maintain a constant delivery of spray. The standard and the reduced swath treatments were done with a coarse fan spray setting, while the pin stream setting provided a very narrow but concentrated spray. To apply the standard 1x1 ft treatment we did two passes of 8.4 secs each (7 ml of 0.06% solution/sec) to cover 10 linear ft, one pass of a 1-ft-wide band going up the home foundation and the other pass for the 1-ft wide segment away from the wall. For the 6x6 in band we did one pass at 8.4 secs (also 7 ml/sec) that treated 6 in up and 6 in out from the wall. For the pin stream (1x1 in band) we did one pass at 11.8 secs (5 ml/sec).

At the garage door/driveway interface all homes received a pin stream (1 in x 1 in) application. This treatment was done because we have previously shown that careful application of a crack and crevice pin stream at the expansion joint at the garage door reduced runoff compared to a pin stream applied outside of the expansion joint (Greenberg et al. 2014). Furthermore, PMPs are willing and able to do this reduced application at the garage door without changing equipment.
A.1 Ant Efficacy. Ant numbers were monitored as described above: 1 week pretreatment and at 1, 2, and 4 weeks post-treatment. On treatment days, each house was given 1 of the 3 treatments; these 3 houses were therefore treated as a block in a randomized block design and there were 7 blocks of 3 houses. Blocking the houses helps to compensate for daily weather variability. Runoff and efficacy of treatments were done with the same 21 houses.

A.2 House Runoff. Runoff trials were concurrent with the tests of efficacy described above. However, two of these homes had unusual configurations of the garage and driveway and we decided not to include them in the water collection data, leaving 19 houses for data analysis. As in the above, we did a randomized block design in the analysis for differences among treatments; each group of 3 houses formed one block. Most of these houses had received fipronil treatments 1 yr before.

Pretreatment and 1 and 30 days post-treatment, driveways were washed with a hose from the width of the garage door to a dam 20 feet away where a 1 L sample was collected. The volume of water needed to collect the 1 L sample was recorded with a Rain Wave™ gauge attached to the hose. The 1 L water samples were analyzed in the Department of Environmental Sciences (UC Riverside, Riverside, California) for fipronil, fipronil-desulfinyl, fipronil-sulfone, and fipronil-sulfide. As shown in Table 3, the 6x6 in band and the pin stream (1x1 in) band each had half the fipronil mass of the standard treatment.

B. Results

B.1 Ant Treatments

There were no significant differences in ant reductions among treatments at any of the assessment dates. However, at 4 weeks after treatment, the standard 1x1 foot treatment was trending positive (higher reductions) with respect to the others (Figure 12).

B.2. House Runoff

Most of the 2015 pretreatment runoff values were below or near the chronic invertebrate benchmark (11 ppt) for fipronil (all treatments, mean = 16.5 ppt; median = 11.1 ppt), and all were below the acute benchmark (110 ppt) (Fig. 13). However, most day 1 post-treatment values for fipronil and its degradates (Fig. 14) were greater than the fipronil acute benchmark. By comparison, the day 1 runoff amounts from 2014, where no treatment was done on the driveway, were mostly below the fipronil acute benchmark of 110 ppt (Fig. 9). Most of the 2015 30-day post-treatment values for fipronil and its degradates were below or near the fipronil acute benchmark (Fig. 15). In the 2015 trials, there were no significant differences in the amount of runoff from the different treatments at 1 and 30 days after application (Figures 14
and 15). This result was true for fipronil and its degradates. Table 4 summarizes the 30-day post-treatment data; all the median and mean values for fipronil and all of its derivatives were below the fipronil acute invertebrate aquatic benchmark of 110 ppt, except for the fipronil 1x1 ft treatment which had 205.33 ppt. However, most measurements were above the fipronil chronic benchmark of 11 ppt.

C. Discussion

C.1 Ant Efficacy

There were no significant differences among the treatments, suggesting that reduced swath treatments give comparable control to the standard treatment. However, at 4 weeks after treatment, the standard 1x1 foot treatment was trending positive (higher reductions) with respect to the others (Figure 12). But at 4 weeks after treatment, all treatments were giving low ant control. On typical PMP residential accounts, control could be extended by supplementing the fipronil with other insecticides that could be applied around the house. These insecticides could include pyrethroids, boric acid, plant oils, and baits containing hydramethylnon or other Als. With these additional treatments the Argentine ant control rates would be higher than those obtained here.

C.2 House Runoff

During 2015, all fipronil house treatments received a pin stream application to the driveway/driveway area (with different band widths around the rest of the house). There were no significant differences in the amount of pesticide runoff between these treatments. Because only the garage door/driveway area was hosed down, we likely did not invoke runoff from other treated areas around the house. However, this study shows that the driveway is a major conduit for runoff during wash-off events (rain, irrigation) and that runoff from a pin stream application (which has reduced treated area over a conventional application) can still result in concentrations of fipronil in runoff that may be toxic to aquatic organisms. This study also suggests that fipronil should not be applied within 1 month prior to the California’s rainy season to avoid highest concentrations of fipronil into urban surface waters. But because fipronil was detected at levels above the chronic US EPA benchmark at samples collected prior to treatment (“pretreatment”) and at 30 days after treatment, it is likely that fipronil (and degradates) are consistently in the urban environment at very low concentrations. Future work should investigate the runoff and mechanism from treated areas other than the garage door/driveway area.
V. Overall Conclusions

1. Low concentrations of bifenthrin and fipronil persist in the environment (Section III, A.3; Section IV, B.2 and Fig. 13);
2. Driveway is a major conduit for runoff during wash-off events (rain, irrigation) (Section III B.2.1 and Section IV C2);
3. Bifenthrin and fipronil should not be applied prior to irrigation or rain. For fipronil, a 30-day rain free period is suggested (Section IV, B.2 and C.2). For bifenthrin, the rain-free period should be > 1 day after application (further work needed) (Section III, A.3);
4. Narrow band (e.g., pin stream) applications may not fully mitigate bifenthrin or fipronil runoff. No application to the garage door area lessens runoff (bifenthrin: Section III, A.3, Section III B2.1, and Fig. 7, 8; fipronil: Section III B.2.1, Section IV B.2, and Figs. 9, 14);
5. When bifenthrin or fipronil is applied to the house perimeter but not to the garage door area, effective initial ant efficacy can be achieved (Section III B.2.2, Figs. 10, 11). Residual ant efficacy is uncertain (Figs. 10, 11, Greenberg and Rust 2017);
6. Bifenthrin applied as a very narrow band around house foundations can give similar levels of ant control as a broad band (2 ft x 3 ft) treatment (Section III B.2.2, Fig. 10).

VI. References

Table 1. Treatments on east side of wall using 0.062% bifenthrin in 2014. The label rate is constant for each unit area. Each wall segment is 3 ft wide.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Bifenthrin Al Concn. (%)</th>
<th>Area sprayed</th>
<th>Vol. Of Spray (ml)</th>
<th>Al (g/ ft²)</th>
<th>Total Al (g)</th>
<th>Spray time (sec)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 ft up by 3 ft out</td>
<td>0.062</td>
<td>15 ft²</td>
<td>56.78</td>
<td>0.00235</td>
<td>0.0352</td>
<td>11.4</td>
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<td>1 ft up by 1 ft out</td>
<td>0.062</td>
<td>6 ft²</td>
<td>22.71</td>
<td>0.00235</td>
<td>0.0141</td>
<td>4.5</td>
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<tr>
<td>2 in up by 2 in out</td>
<td>0.062</td>
<td>1 ft²</td>
<td>3.79</td>
<td>0.00235</td>
<td>0.00235</td>
<td>0.54</td>
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</table>

Table 2. Treatments on west side of wall using various concentrations of bifenthrin in 2014. The total Al used is the same for each wall segment. Each wall segment is 3 ft wide.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Bifenthrin Al Concn. (%)</th>
<th>Area sprayed</th>
<th>Vol. of spray (ml)</th>
<th>Al (g/ ft²)</th>
<th>Total Al (g)</th>
<th>Spray time (sec)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 ft up by 3 ft out</td>
<td>0.062</td>
<td>15 ft²</td>
<td>56.78</td>
<td>0.00235</td>
<td>0.0352</td>
<td>11.4</td>
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<tr>
<td>1 ft up by 1 ft out</td>
<td>0.097</td>
<td>6 ft²</td>
<td>36.3</td>
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<td>0.0352</td>
<td>7.3</td>
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<tr>
<td>2 in up by 2 in out</td>
<td>0.16</td>
<td>1 ft²</td>
<td>22</td>
<td>0.0352</td>
<td>0.0352</td>
<td>3.1</td>
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</tbody>
</table>
Table 3. Description of the 3 fipronil treatments at houses in 2015. For the 1x1 ft and 6x6 in band widths, n=6; for the 1x1 in pin stream treatment n=7. All treatments received a pin stream application to the garage door area.

<table>
<thead>
<tr>
<th>Treatment (Contract Treatment Identifier)</th>
<th>Treatment swath at base of wall</th>
<th>Projected treatment area</th>
<th>Actual amount of fipronil (AI)/ cm²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Labeled rate (standard treatment) (A)</td>
<td>1 foot up, 1 foot out band application</td>
<td>2 quarts a of 0.06% Termidor® SC preparation per 160 linear feet (320 square feet) (0.2 fl. oz/ft²)</td>
<td>3.8 µg</td>
</tr>
<tr>
<td>Pin Stream (C1)</td>
<td>1 inch up, 1 inch out pin stream application</td>
<td>1 qt. of a 0.06% Termidor® SC preparation per 160 linear feet (26.67 square feet) (1.2 fl. oz/ft²)</td>
<td>22.9 µg</td>
</tr>
<tr>
<td>Reduced swath (D)</td>
<td>6 inches up, 6 inches out band application</td>
<td>1 quart of a 0.06% Termidor® SC preparation per 160 linear feet (160 square feet) (0.2 fl. oz/ft²)</td>
<td>3.8 µg</td>
</tr>
</tbody>
</table>
Table 4. Thirty day post-treatment house runoff medians and means in ppt. The fipronil chronic aquatic benchmark = 11 ppt; the fipronil acute aquatic benchmark = 110 ppt. All values are below the acute aquatic benchmark (except for the figure in bold) but only several were below the chronic benchmark (shown in italics). For the 1x1 ft and 6x6 in band widths n=6; for the 1x1 in treatment n=7.

<table>
<thead>
<tr>
<th>Compound</th>
<th>1x1 ft</th>
<th>6x6 in</th>
<th>1x1 in</th>
</tr>
</thead>
<tbody>
<tr>
<td>Medians (ppt)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fipronil</td>
<td>88.25</td>
<td>64.26</td>
<td>64.13</td>
</tr>
<tr>
<td>Desulfynil</td>
<td>81.77</td>
<td>21.78</td>
<td>22.75</td>
</tr>
<tr>
<td>Sulfide</td>
<td>33.11</td>
<td>27.67</td>
<td>25.95</td>
</tr>
<tr>
<td>Sulfone</td>
<td>3.80</td>
<td>3.28</td>
<td>0.0</td>
</tr>
<tr>
<td>Means (ppt)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fipronil</td>
<td><strong>205.33</strong></td>
<td>53.05</td>
<td>54.62</td>
</tr>
<tr>
<td>Desulfynil</td>
<td>90.90</td>
<td>38.99</td>
<td>52.37</td>
</tr>
<tr>
<td>Sulfide</td>
<td>40.05</td>
<td>28.00</td>
<td>27.97</td>
</tr>
<tr>
<td>Sulfone</td>
<td>22.55</td>
<td>12.63</td>
<td>5.22</td>
</tr>
</tbody>
</table>
Figure 1. One side of constructed wall showing 12 3-ft wide segments.

Figure 2. Collecting a 1 L water sample for analysis.
Figure 3. Masking an area to be treated. This example was 2-ft up and 3 ft out from the wall.

Figure 4. (A) Sucrose water vial with ants feeding on the solution. (B) Flower pot covers vial.
Figure 5. Dam for collecting water sample on driveways.

Figure 6. Collecting the water sample.
Figure 7. Runoff of bifenthrin from concrete wall and pad 1 day post-treatment in 2014 trials. Graph shows mean runoff (4 replications per treatment) with standard error bars. Bars with the same letter are not significantly different. (A) Label rate (1 oz Talstar® P (finished solution of 0.062% bifenthrin Al)/1000 ft²) constant for different band widths. (B) Total amount of bifenthrin active ingredient constant (0.0352 g) for different band widths. Each treatment had 4 replications.
Figure 8. Runoff of bifenthrin (treatment means of five replications) from Riverside homes in 2014 with standard error bars. ‘CC’ in the legend refers to a crack and crevice application along the lawn-driveway edge. Bifenthrin was not applied at the garage door area in any of the treatments.
Figure 9. Fipronil runoff from Riverside homes in 2014. No treatment was done on the driveway. Mean of 5 replications for 6x6 in and pin stream rain treatments with standard error bars. Pin stream alone treatment had 10 replications.
Figure 10. Efficacy of bifenthrin house treatments in 2014. ‘C&C’ in legend refers to a crack and crevice application along the lawn-driveway edge. Treatment means (5 replications each with standard error bars). Bifenthrin was not applied at the garage door area.
Figure 11. Efficacy of fipronil treatments at Riverside homes in 2014. ‘Pin+Rain’ in legend refers to unexpected monsoonal downpour after a pin stream application at 5 homes. Negative values are an increase in ant numbers. In these trials, no treatment was applied on the driveway or garage door area.
Figure 12. Efficacy of fipronil treatments against Argentine ants in Riverside during 2015. Mean of 6 treatments (1x1 ft and 1x6 in) and 7 treatments (pin stream) with standard error bars. All treatments received a pin stream application to the garage door area.
Figure 13. Pretreatment runoff values for fipronil and its degradates at homes used in 2015. ‘Acute’ and ‘chronic’ refer to fipronil aquatic invertebrate benchmarks (see text). Mean of 6 treatments (1x1 ft and 1x6 in) and 7 treatments (pin stream) with standard error bars.
Figure 14. Day 1 runoff values for fipronil and its degradates at homes used in 2015. ‘Acute’ and ‘chronic’ refer to fipronil aquatic invertebrate benchmarks (see text). All treatments received a pin stream application to the garage door area. Mean of 6 treatments (1x1 ft and 1x6 in) and 7 treatments (pin stream) with standard error bars.
Figure 15. One month post-treatment values for fipronil and its degradates at homes used in 2015 trials. ‘Acute’ and ‘chronic’ refer to fipronil aquatic invertebrate benchmarks (see text). All treatments received a pin stream application to the garage door area. Mean of 6 treatments (1x1 ft and 1x6 in) and 7 treatments (pin stream) with standard error bars.