Reinvasion and Boundary Control of Argentine Ants in Urban Areas

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1. Background

In October 2011, Tasman District Council undertook a trial of spring baiting of Argentine ants in residential sections using Xstinguish™ Argentine ant bait, and sought information on how quickly individual properties were reinvaded. Following on from this, Regional Councils have contributed funding for field trials to determine the effectiveness of a range on insecticide treatments on different ground surfaces for slowing the reinvasion of Argentine ants. The analysis and reporting of results presented here has been funded by Envirolink Project TSDC 83 for Tasman District Council and completed by Entecol Ltd under contract to Landcare Research.

2. Introduction

Argentine ants (*Linepithema humile*) have been established in New Zealand since 1990 (Green 1990), and are a major pest for householders and a recognised threat to biodiversity and horticulture (Harris 2002; Vega & Rust 2001; Ward *et al*. 2010). They have now spread into many towns and cities throughout the North Island and northern South Island, primarily through accidental human-mediated dispersal of propagules (Ward *et al.* 2005).

Unlike many other ant species, Argentine ant queens do not disperse by flight, but rather by a process of "budding", in which a queen and workers split off from an existing nest to form a new colony close by. This limits the natural spread of Argentine ants to about 150m per year (Suarez *et al.* 2001). However, the individual nests within an area remain highly cooperative and form super-colonies to dominate resources. The nests are also very mobile over the warmer months, and will rapidly relocate themselves in response to disturbance, physiological conditions, and to be closer to food resources (Hertzer 1930; Newell & Barber 1913), with more than 40% of nest sites occupied for less than a month (Heller & Gordon 2006). As a result, Argentine ant populations can be highly dynamic at both site and landscape scales (Menke *et al.* 2007; Ward & Stanley 2012).

Given the dynamic nature of Argentine ant infestations, reinvasion is likely to be a significant issue when controlling populations within a site that is part of a wider infestation. Well-coordinated baiting operations over entire infestations, such as that on Tiritiri Matangi, have achieved successful long-term control (Harris *et al.* 2002), and even approached eradication (Chris Green, pers. comm.). However, in urban and residential areas, the coordinated management of Argentine ant infestations is severely hampered by small land holdings and a multitude of owners and occupiers. Treatment of Argentine ant infestations in these areas are often piece-meal, with some properties not undertaking control at all, and others using a variety of treatments applied at different times. As result, residents often report that results are disappointing and control is short-term.

Xstinguish™ Argentine ant bait has previously been recommended for mid-summer application (when ant foraging activity is likely to be at its highest level), but recent research has shown that it can also provide excellent control when applied in the spring, when it has the potential to target the new-season reproductives while they were still larvae and provide control for a longer period of the year (Toft 2011). Before fully advocating the use of spring baiting to property owners, Tasman District Council sought to trial this approach on a number of properties with either Argentine or Darwin's ants (*Doleromyrma darwiniana*) to determine whether spring baiting alone was able to provide prolonged control in a typical urban situation where properties were baited individually or in small clusters, rather than conducting wide-area baiting over entire infestations. The risk is that reinvasion from adjoining properties would quickly negate the effect of spring baiting on treated properties.

The Tasman District Council also wanted information on the rate of reinvasion into a trial plot of pasture, as the solidly vegetated ground surface of pasture was expected to slow the rate of reinvasion in comparison to residential and business areas where there is often extensive areas of pavement. Results from these trials will provide better guidance on what to expect from baiting programmes in different situations.

With the threat of reinvasion identified as a significant issue for urban control of Argentine ants, there is a need to assess the potential for boundary treatments to limit reinvasion from adjacent untreated properties. There are a number of ant control products now available in New Zealand for treating surfaces, but little specific information on their utility for providing ongoing protection of boundaries. Another complication is that the ground surface around the boundaries of properties is also highly variable and on a single property it can range from lawn and garden surfaces to gravel driveways or sealed concrete and bitumen. Insecticide treatments can perform differently depending on the surface types. In the trials reported here we looked at the use of granular insecticides for treating lawns and garden surfaces, and a variety of surface sprays for treating concrete, bitumen, and gravel surfaces.

3. Objectives

- Determine the time to reinvasion/recovery by Argentine or Darwin's ants in urban properties baited with Xstinguish™ Argentine ant bait in spring.
- Determine the time to reinvasion by Argentine ants in an area of grazed pasture that was baited with Xstinguish™ Argentine ant bait in spring.
- Investigate the use of 3 types of granular insecticides for providing protection from reinvasion by Argentine ants across lawn and garden surfaces.
- Investigate the use of 3 types of insecticide sprays for providing protection from reinvasion by Argentine ants across concrete, bitumen and gravel surfaces.

4. Methods

4.1 Reinvasion of urban properties

A total of 25 properties (21 residential, 4 commercial) infested with Argentine ants were selected for spring baiting treatment in the Nelson/Tasman region. Ten of these were treated as individual properties (average size = 635 m^2, range = 450–1,090 m^2), and the remainder formed five separate clusters of 2 – 4 adjoining properties (average cluster size 2090 m^2, range 1120–3170 m^2). All of these properties were baited in the second week of October 2011 using Xstinguish™ Argentine ant bait on a standard 2 x 2 m grid, with increased baiting densities in sites of high ant numbers, such as barked gardens. At the same time, four individual residential properties (average size = 766 m^2, range = 733–814 m^2) that were infested with Darwin's ants were also baited with Xstinguish™.

Ant abundance at each property was monitored using the baited tile method (described in the in the online Argentine ant toolkit, http://argentineants.landcareresearch.co.nz), using a transect of 12 ceramic tiles with a highly attractive non-toxic ant bait ("Inform") in the centre. Baited tiles were left out for 1 hour and then photographed with a digital camera to obtain an instantaneous count of ant activity on the surface of each tile. Ant populations on each property was assessed a day or two before baiting, and then once per month for up to 4 months, with monitoring ceasing for any given property when it was clear that ants had "reinvaded" the property. Reinvasion was said to have occurred when the mean numbers of ants on baited tiles returned to a level that was at least 50% of pre-baiting levels. This information was supplemented by recorder observations on the general prevalence of ants and trails present on the property, so on properties where relatively few ants were recorded on tiles there was still a good indications whether ants were back to potential nuisance levels.

4.2 Reinvasion of pasture land

A 50 x 50 m (0.25 ha) plot of pasture was baited with Xstinguish™ Argentine ant bait on a 2 x 2 m grid in mid October. The population of Argentine ants in the plot was assessed using the baited tile method using 3 parallel lines of tiles, with one line through the centre of the plot, and the two other lines 10 m in from opposite sides. The first tile in each line was placed c. 10 m in from the edge of the plot and then at 4 m intervals so there was a total of 8 tiles per line. Ant populations were assessed immediately prior to treatment and then after 1 week, 2 weeks, 4 weeks, 2 months, and 3 months after treatment. This arrangement allowed us to measure recovery of the ant populations inside the plot and also to determine whether the increase occurred firstly from the outside of the plot.

4.3 Trials of granular insecticides on lawn and gardens

A total of eighty 1.5 × 1.5 m square plots were marked out on a large property infested with Argentine ants. Forty of the plots were on mown lawn and the other forty were on gardens covered with landscaping bark mulch. There was a minimum of 3 m between plots. For each surface type (lawn or garden), four treatments were applied to each of 10 plots:

- Control – no insecticide applied
- Ant Stop G granular insecticide (50g/kg chlorpyrifos) – applied at label rate of 2g/m^2
- Biforce™ granular insecticide (2g/kg bifenthrin) – applied at high label rate of 22 g/ m^2
- No Ants Ant Sand (2g/kg bifenthrin) – applied at high rate of 22 g/ m^2

Treatments were applied on 6 March 2012. Granules were spread evenly on the plots using hand-held dispensers, but each dispenser was only used for a single treatment type. Each plot (including the controls) was then gently watered with 2 litres of clean water from a mist sprayer to activate the granules without washing them out of the plots.

The level of ant activity was measured using a baited tile placed in the centre of each plot. In order for ants to recruit to the baited tile, they would have to move across a 75 cm width of treated surface from any direction, so it was similar to measuring the ability of ants to recruit to resources across a 75 cm-wide treatment strip around a boundary. It was possible ants would be able to forage across a treated strip but be lethally affected, however we felt it was unlikely that ants would be successfully recruit to bait (i.e. foragers walking to bait and back to nest to start recruitment) if the boundary treatment was effective. Therefore, as well as getting a mean number of ants per plot, we looked at the proportion of baits with more than 5 ants feeding after 60 minutes as an indication of recruitment.

Ant activity in the plots was measured once in the morning before treatment and then 1 week, 2 weeks, and 4 weeks after treatment.

4.4 Trials of surface sprays on sealed and gravel surfaces

The effectiveness of residual insecticide sprays was examined on three surface types: bitumen, concrete, and gravel. For each surface type, four separate plots of at least 5 m^2 were marked and treated with one of the following treatments:

- Control – no insecticide applied
- Arilon® (20% indoxacarb in a water-dispersal granule) – mixed at 5 g/L water
- Biff Ant® (80g/L bifenthrin in suspension concentrate) – mixed at 15 ml/L water
- Termidor® (100g/L fipronil in suspension concentrate) – mixed at 6 ml/L water

The mix rates used were the rates recommended on the product labels, with the highest rate chosen if there were two different rates suggested. All plots of all surface types were treated on 7 March 2012. A separate hand sprayer unit was used for each type of spray, and these had previously been used only with water or the same insecticide product, so there was no chance of contamination with other chemicals. Because each sealed surface had a different absorption rate, they were sprayed until thoroughly wet with a shining coat on the surface, but not quite running off and pooling.

To measure the effectiveness of the treatments on bitumen and concrete, individual Argentine ants were placed on the treated surface for 10 – 15 seconds (about the time they would take to walk across a treated boundary strip) and then retained in a pottle and their health monitored after 1, 2, 4, and 8 hours, and then at practical intervals up to 48 hrs. Twenty ants were exposed to each type of treated surface (including untreated controls), with each ant in its own container. A small square of filter paper soaked in sugar solution was also placed in the container to provide moisture and energy requirements.

To measure the effectiveness of the treatments on gravel surfaces, we placed one piece of treated gravel in the small container with an ant for a period of two minutes, both to ensure the ant had plenty of contact with the gravel and to account for ants taking longer to walk across structured surfaces like gravel (e.g. Kafle *et al*. 2009). The gravel was then removed and ant survival measured as for the bitumen and concrete trials.

The relative effectiveness of surface treatments was tested at 2 days, 1 week, 2 weeks, and 3 weeks after spraying.

5. Results

5.1 Reinvasion of urban properties

After 1 month, 60% of the single properties (treated in isolation), and 27% of properties that were treated as part of a cluster had Argentine ant numbers at levels of at least half the pre-treatment level. Indeed, several properties had marked increases in ant numbers from pre-treatment levels after 1 month.

The effect of spring baiting did, on average, last longer on properties treated as part of a cluster than in individual properties (Fig. 1), but none remained under control longer than 3 months.

Ironically, the property that took the longest to reach the 50% population reinvasion mark was also one the smallest of the individual properties (450 m^2), but this property also had by far the highest numbers of ants before treatment, so the threshold for "reinvasion" was an anomaly and much higher than other properties. If using average ant density over all properties as a guide, reinvasion on this property actually occurred after 2 months.

The four individual properties with Darwin's ants were all reinvaded after one month.

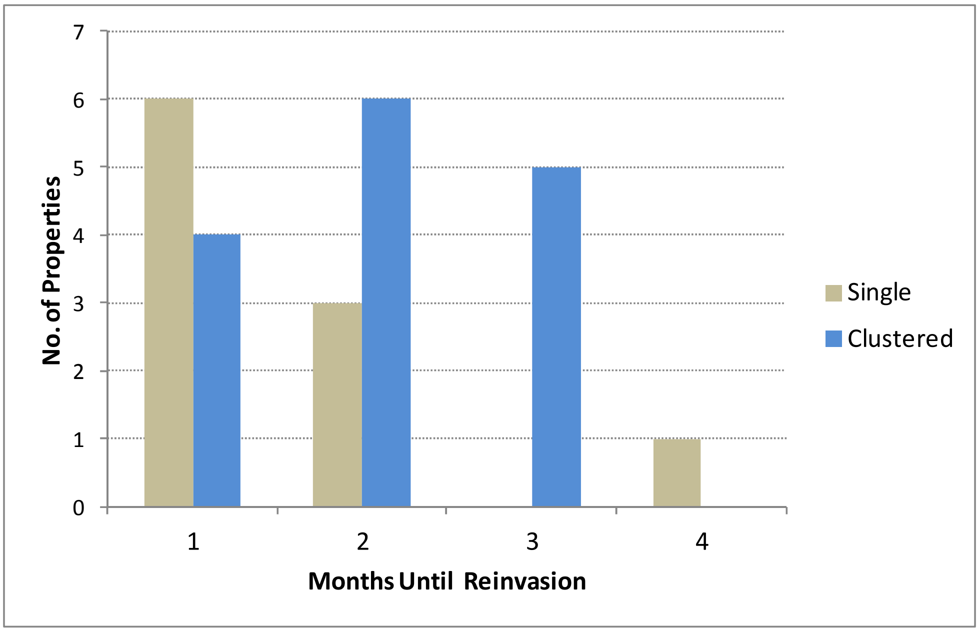


Figure 1: The frequency of months to reinvasion by Argentine ants for properties baited in spring either as single properties (10 total) or as part of a cluster (15 total). Reinvasion was considered to have occurred when ant numbers returned to at least 50% of the before-baiting value.

5.2 Reinvasion of pasture

Prior to baiting, Argentine ants were detected at 18 of the 24 grid points within the plot, although there was a concentration of activity along one side of the plot in particular, and one corner with no ants detected (Fig. 2a). Baiting was successful at substantially reducing ant activity within the plot, with only 3 grid points recording any Argentine ants one week after baiting, and with the highest activity (14 ants) at the outside corner where there was high activity before baiting (Fig. 2b). Over the following weeks, the numbers of Argentine ants in the plot steadily increased from the side of high activity and reaching the centre of the plot after a month (Figs. 2c+d). The numbers of grid points recording Argentine ants also increased with time, reaching 16 of 24 after 3 months (Fig. 3), but the side most distant from the invasion edge remained free of ants (Fig. 2f).

5.3 Trials of granular insecticides on lawn and gardens

There were no significant differences in the mean numbers of ants recorded in plots prior to treatment for either the lawn or bark garden plots. One week after treatment, the mean counts for all three insecticide treatments were significantly lower than their pre-treatment counts (Figs. 4a + b). The average for untreated controls was also down from the previous week, but this was not significant.

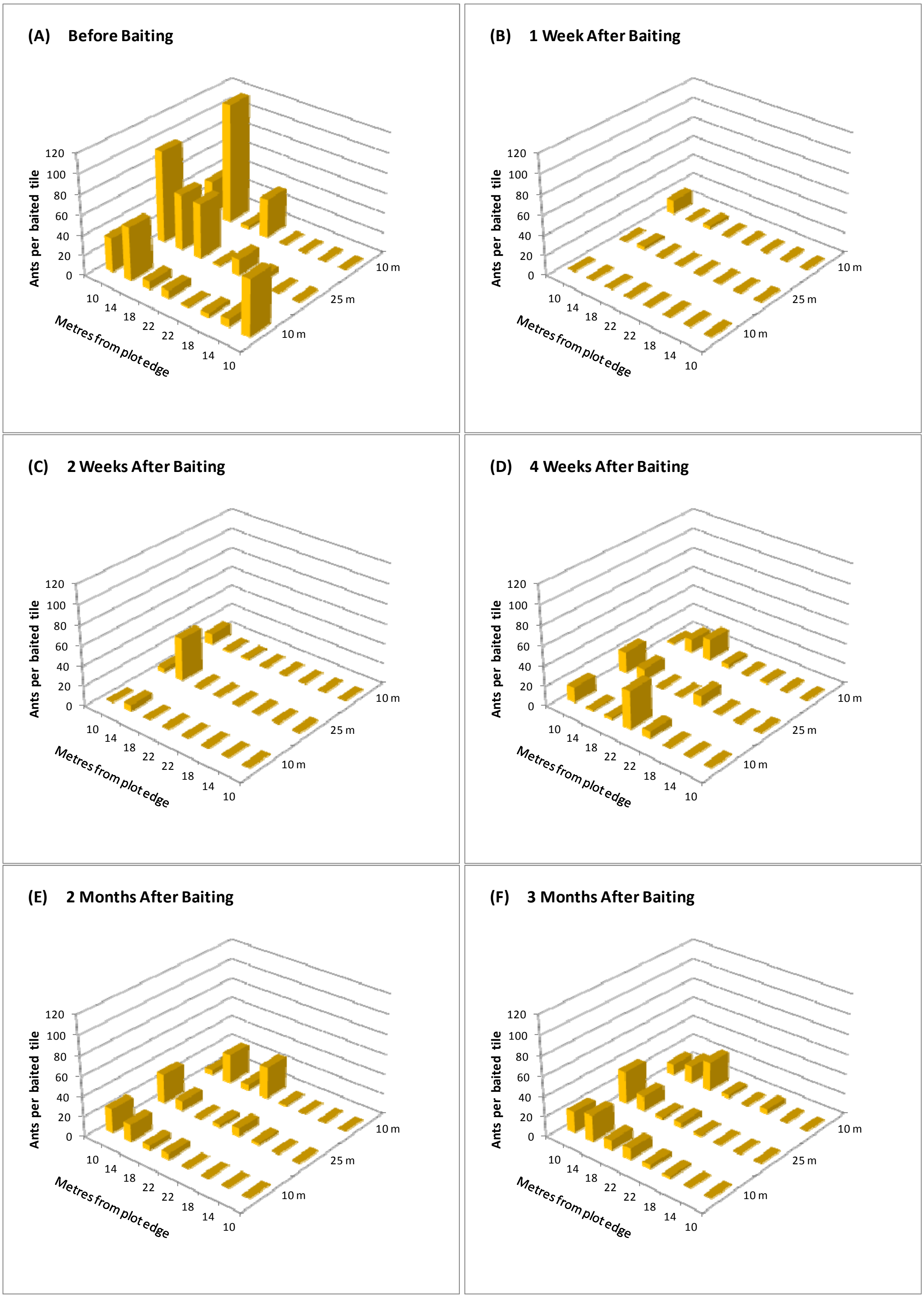


Figure 2: Graphical representation of the reinvasion of Argentine ants into a 50 × 50 m pasture plot after baiting with Xstinguish Argentine ant bait in spring.

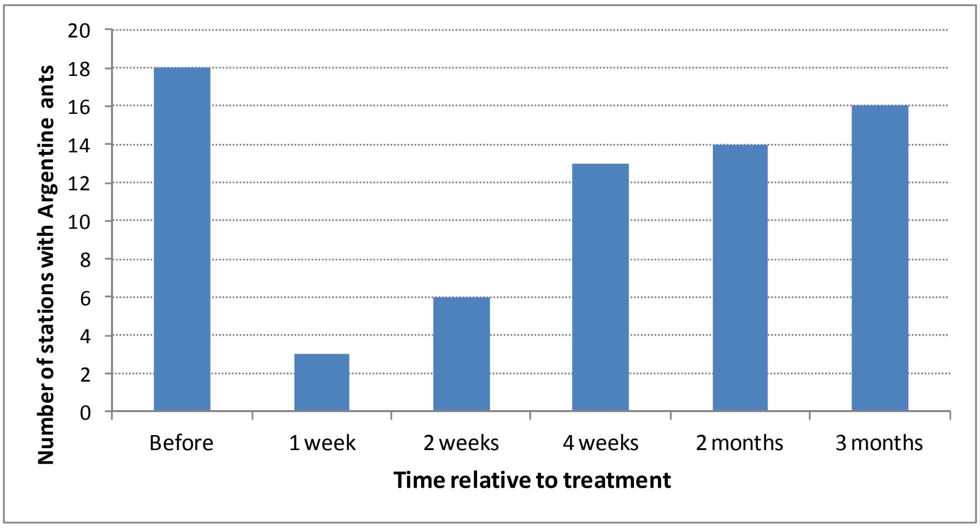
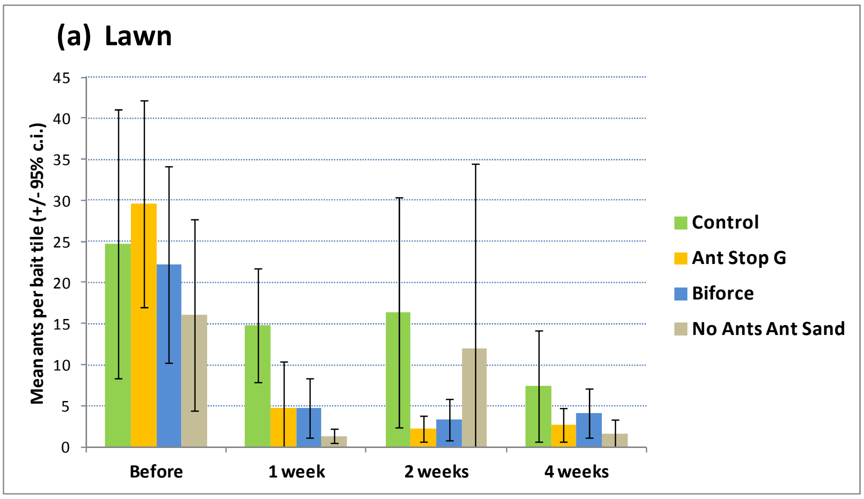


Figure 3: The number of station grid points (24 maximum) where Argentine ants were detected in a 50 × 50 m plot of pasture that was baited with Xstinguish bait in spring.



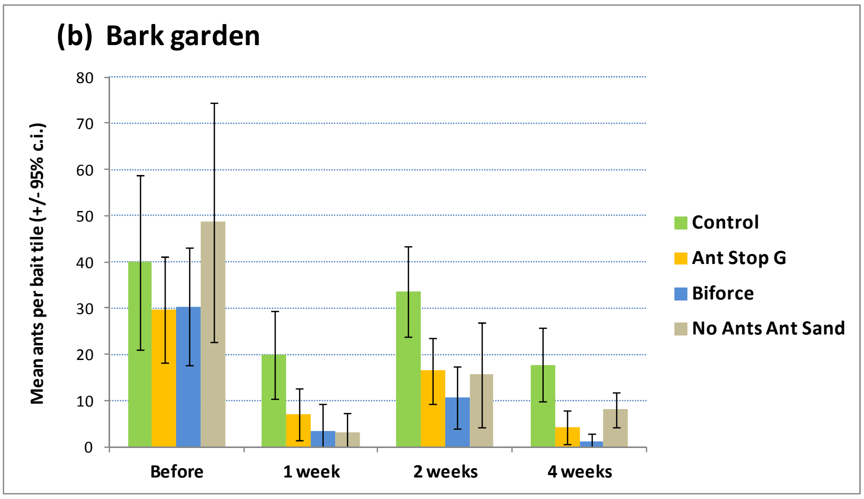


Figure 4: Mean numbers of ants on baited tiles in the centre of plots treated with various granular insecticides in (a) lawn, and (b) garden with bark mulch.

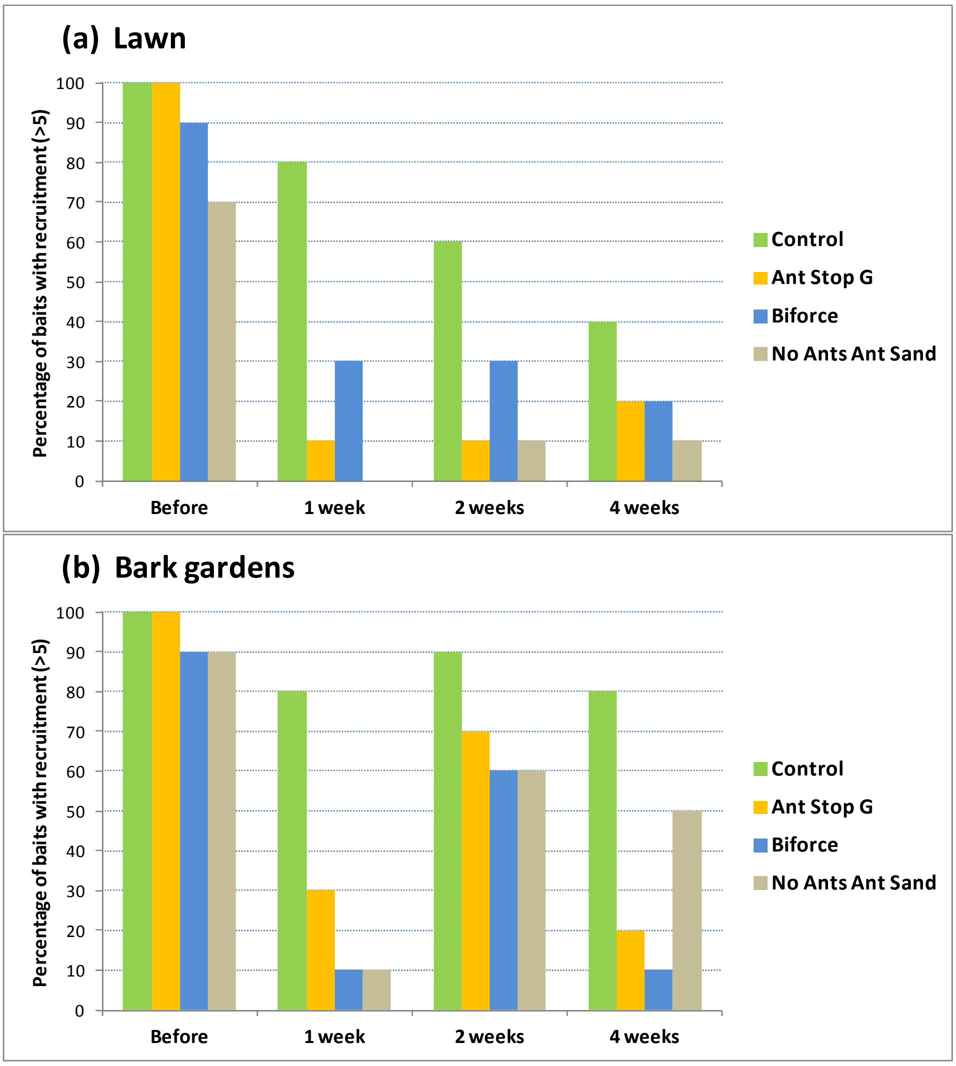


Figure 5: The proportion of treated plots in which Argentine ants were recruiting to baited tiles in the centre.

After 2 weeks, there was more variability between plots, particularly in the lawn plots, and the mean for the No Ants Ant Sand treatment was greatly skewed by one tile having 115 ants recruited to the bait, whereas the other 9 plots of this treatment were all either nil or 1 ant. Amongst the bark garden plots, both the Ant Stop G and Biforce treatments recorded significantly fewer ants than the untreated controls (Fig. 4b).

After 4 weeks, the mean counts in the plots treated with insecticides were still lower than that in untreated plots for both lawn and bark garden surfaces, but the difference was only significant in the bark garden plots (Figs. 4 a + b).

After 1 week in the lawn plots treated with any of the three insecticides, there was a notable decline in the proportion of plots with more than 5 ants recruited to the baits, and this low level of recruitment was sustained for the next 4 weeks (Fig. 5a). There was also a slow decline in recruitment at the untreated control plots over the same period, so although the untreated plots consistently had the highest levels of recruitment for the four weeks after treatment, the difference in recruitment between treated and untreated plots declined.

In the bark garden plots, there was the same distinct drop-off in recruitment to baits in the week after treatment for those plots treated with any of the insecticides, but there was quite a resurgence of recruitment levels (at least 60%) after 2 weeks (Fig. 5b). The recruitment levels to baits dropped off again 4 weeks after treatment for the Biforce and Ant Stop G in the bark garden plots, but remained relatively high (50%) for the No Ants Ant Sand.

5.4 Trials of surface sprays on sealed and gravel surfaces

Concrete

Two days after spraying it was clear that all three surface treatments were providing excellent control on concrete, with less than 20% of ants surviving 2-hours after contact with any treatments (nil survival in the case of Biff Ant), and all ants exposed to any treatment were dead within 24 hrs (Fig. 6a). One week after treatment, the effect of the treatments was slightly slower, but there was still 100% mortality 24 hours after exposure for all treatments (Fig. 6b).

In the second week, the area was exposed to about 22 mm of rainfall on the day immediately preceding the tests, and although the weather had cleared for the test itself, the concrete surface was still clearly damp. It is suspected that this was the primary cause for a distinct drop in performance of the treatments, with from 45 to 65% of ants still healthy after 48 hours (Fig. 6c). The survival of ants was not monitored beyond 48 hours as the untreated control group also begins to experience a few natural fatalities after that period and it becomes increasingly difficult to attribute the cause of mortality within the treated groups to the treatment itself.

Three weeks after treatment (and with no more significant rainfall) there was some improvement in performance for Biff Ant (only 15% surviving after 24 hours) and Arilon (30% surviving) in comparison to the 2-week trial. However, the surface treated with Termidor did not improve following the dry period, with 50% surviving after 24 hours. There was no change in survival rates for any of the treatments after 48 hours (Fig. 6d).

Bitumen

Two days after treatment, the results for bitumen surfaces was similar to those of concrete, with all three treatments performing very well and no ants surviving 12 hours after exposure to the surfaces (Fig. 7a). One week after treatment, there was still nil survival after 12 hours for Biff Ant and Termidor, with the slower-acting Termidor reaching total mortality after 24 hours (Fig. 7b).

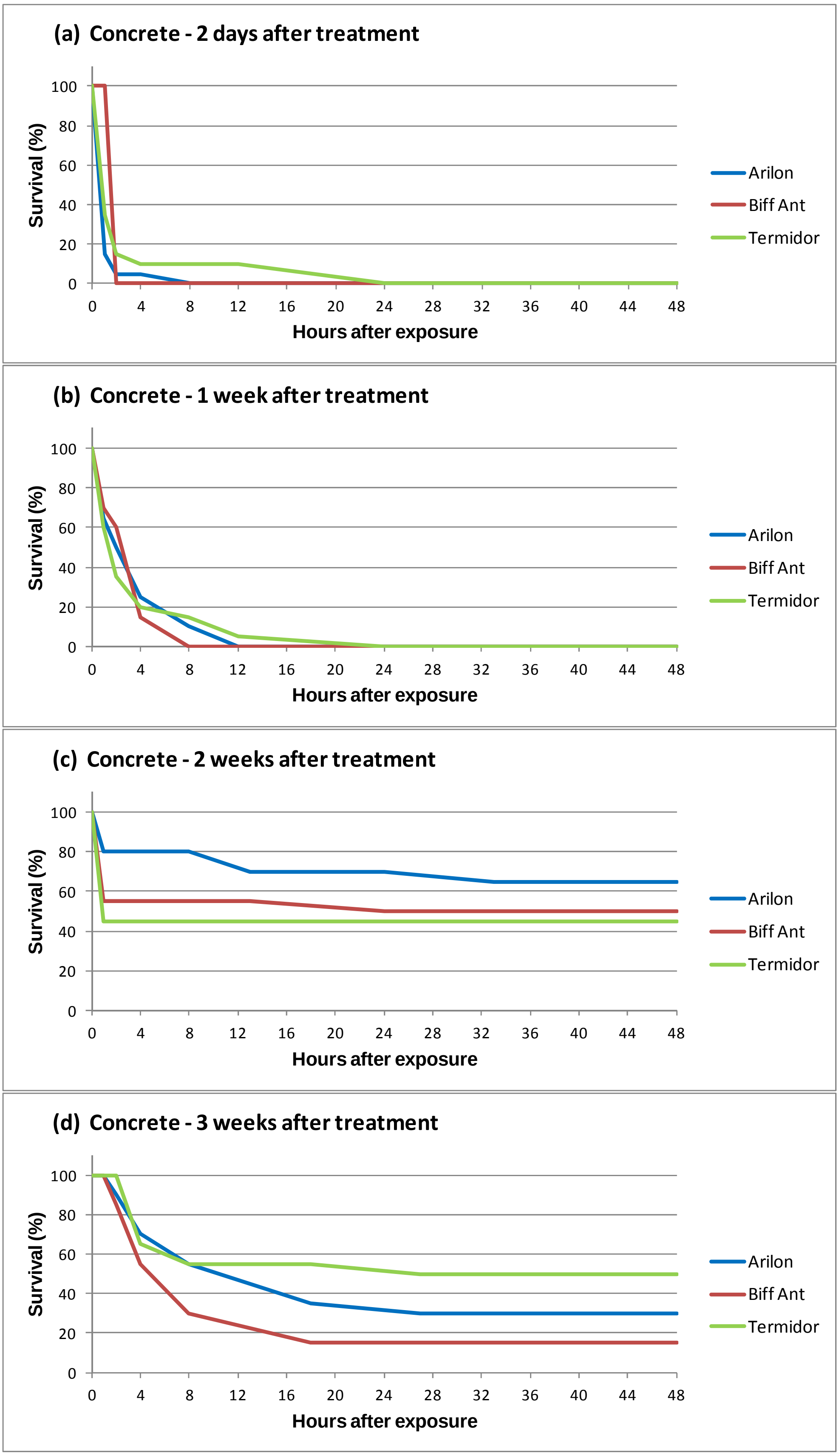


Figure 6: Survival rates over 48 hours for ants exposed to concrete surfaces treated with three different insecticides; (a) 2 days after application, (b) 1 week after, (c) 2 weeks after, and (d) 3 weeks after application.

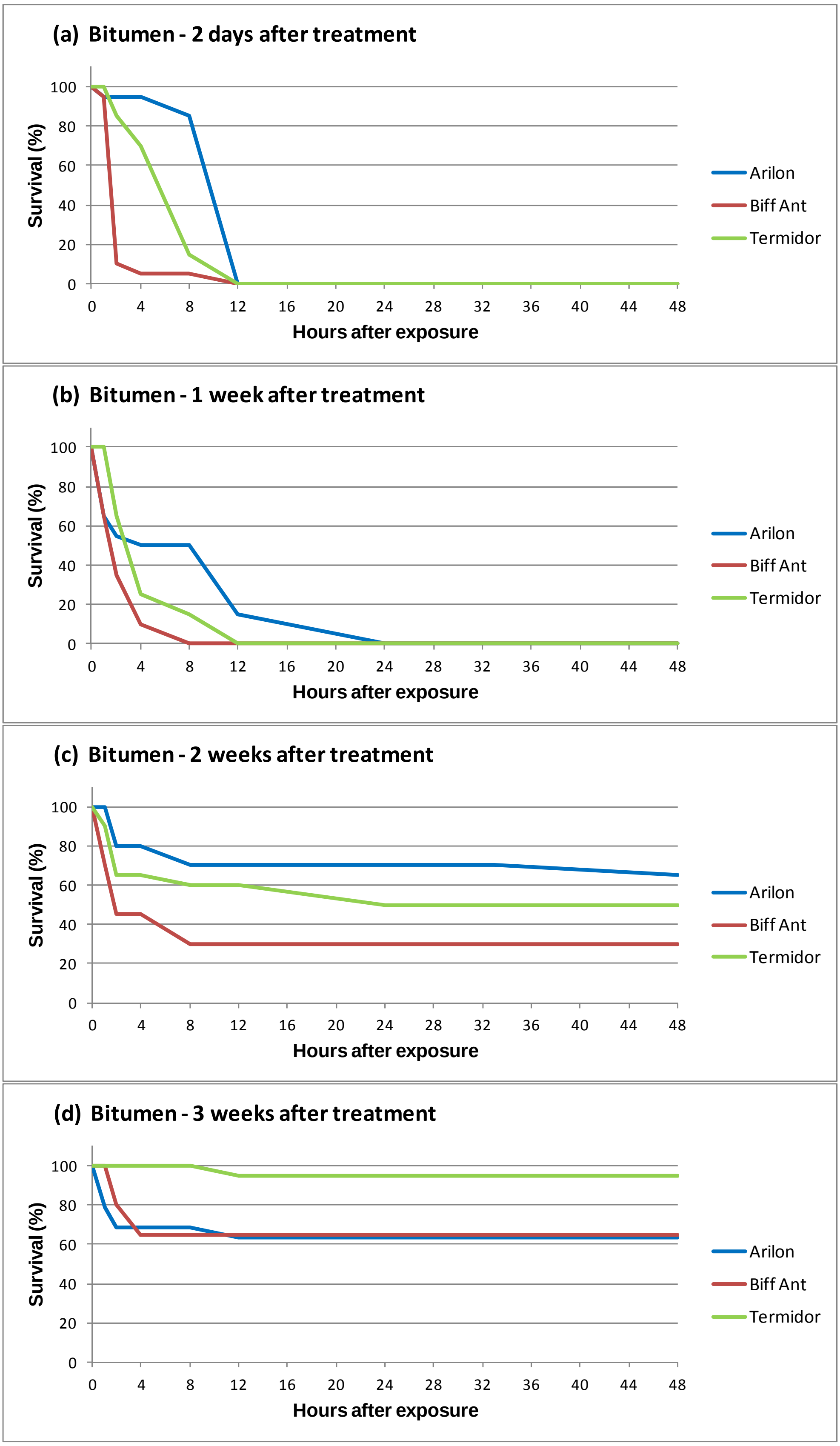


Figure 7: Survival rates over 48 hours for ants exposed to bitumen surfaces treated with three different insecticides; (**a**) 2 days after application, (**b**) 1 week after, (**c**) 2 weeks after, and (**d**) 3 weeks after application.

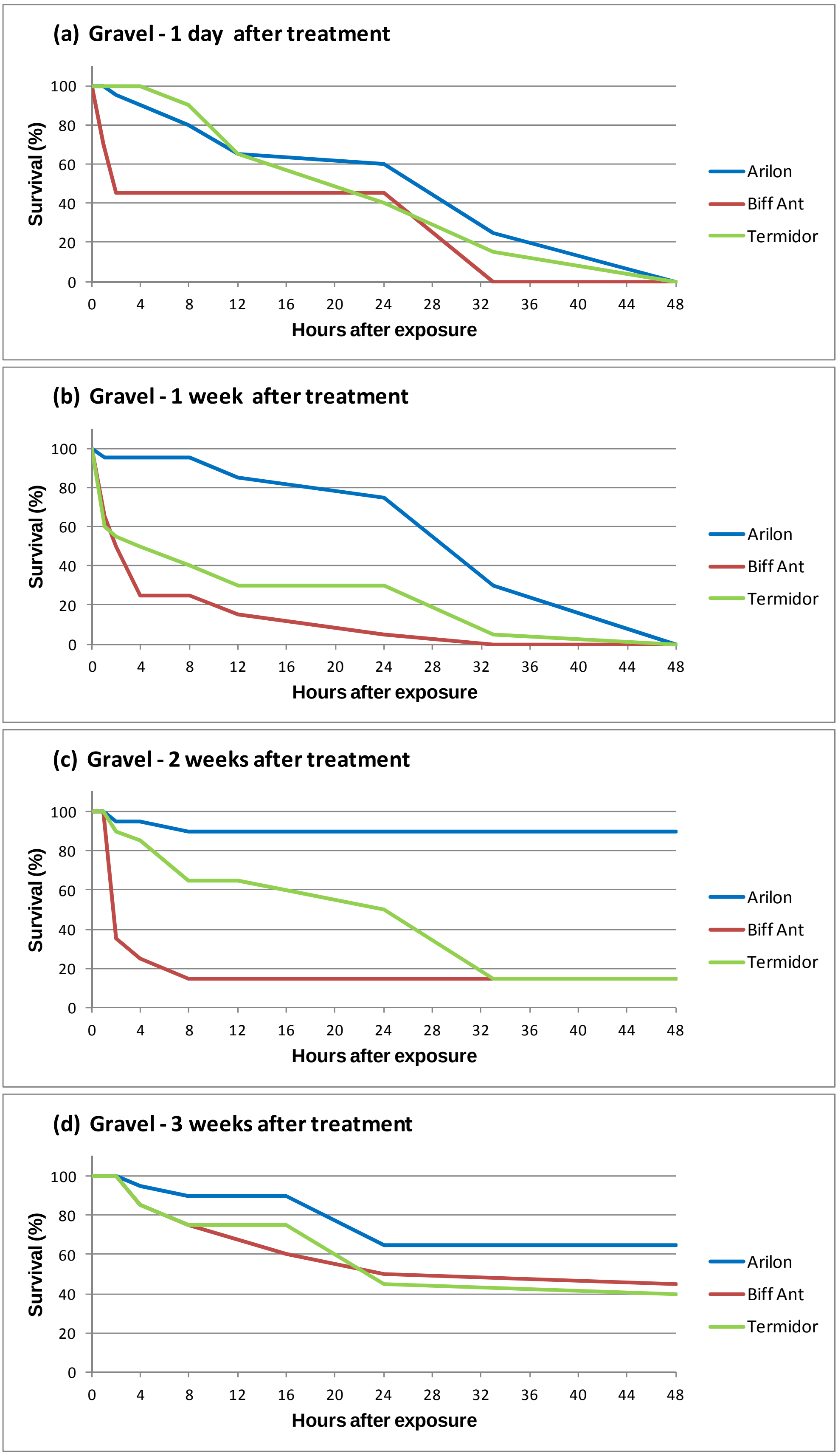


Figure 8: Survival rates over 48 hours for ants exposed to bitumen surfaces treated with three different insecticides; (**a**) 1 days after application, (**b**) 1 week after, (**c**) 2 weeks after, and (**d**) 3 weeks after application.

After the rainfall in week two there was a distinct decline in efficiency (Fig. 7c). Biff Ant performed best of the group, with 30% of ants still surviving 24 hours after exposure, followed by Termidor with 50% surviving. There were no further fatalities for these treatments after 48 hours. Seventy percent of the ants exposed to the Arilon treated bitumen survived after 24 hours, and 65% after 48 hours.

In contrast to the concrete treatment, the efficiency of treatments on the bitumen did not show improvement in the third week (Fig. 7d). About two thirds of the ants exposed to Arilon and Biff Ant surfaces remained healthy 48 hours after exposure. The Termidor treatment experienced the most significant drop in performance after three weeks on the bitumen surface, with 95% of ants still surviving 48 hours after exposure to the surface.

Gravel

The results for gravel were quite different to that of the sealed surfaces. The relative survival rate over time for ants exposed to the gravel was higher than that for concrete and bitumen. One day after treatment, it took 48 hours before all ants that had contacted the Arilon and Termidor treatments died, and 33 hours for all the Biff Ant sample to die (Fig. 8a). The result was about the same 1 week after treatment (Fig. 8b).

There was a decline in efficiency for all treatments two weeks after application and following the rain, with 15% of ants surviving after 48 hours for both Biff Ant and Termidor (although the Biff Ant treatment reached this full level of mortality after 8 hours, compared to 33 hours for Termidor). The Arilon treatment had a low level of efficacy on the gravel after 2 weeks, with 90% of ants still surviving after 48 hours (Fig. 8c).

After 3 weeks and some dry weather, the efficacy of the Arilon appeared to improve somewhat, with 65% of ants surviving after 48 hours. However, the Biff Ant (45% survival) and Termidor (40% survival) still caused a higher level of mortality over 48 hours (Fig. 8d).

6. Discussion

6.1 Reinvasion of urban properties

The reinvasion/recovery of Argentine ants on residential and commercial properties that had been baited in spring was remarkably fast. Properties that were baited individually tended to be reinvaded within a matter of a few weeks, whereas the majority of properties baited as part of a cluster had significantly reduced ant numbers for 2 or 3 months. The clusters we used consisted of only 2 – 4 properties and this meant all properties were likely to have at least one border (e.g. street frontage or at the rear) that was next to an untreated zone, and so there was no special benefit noticed for the central property in the cluster in comparison to the external properties. The benefit would appear to be a more effective control of the population generally when a larger area is baited, as well as having at least one border free from the threat of immediate reinvasion.

Darwin's ants were also quick to come back from spring baiting on the single properties treated. Evidence from annual surveys of Darwin's ant in the region provide good evidence that they are considerably slower to spread than Argentine ants, but the best results from baiting will still come from getting a coordinated effort between multiple property owners to bait the widest area possible.

The speed of reinvasion for both species demonstrates that if individual property owners are coordinating the baiting on their own properties, it is also important that the road verges fronting those properties have ant management in place, and that this management should be undertaken around the same time to maximize the benefits for the neighborhood as a whole.

6.2 Reinvasion of pasture

The reinvasion of the pasture plot following spring baiting was slower than observed for the residential properties. It is likely that one of the main reasons for this is that dense grass is considerably more difficult for ants to move through in comparison to a residential area, that inevitably contain a range of fast-track routes such as sealed driveways, paved patios and pathways, concrete curbing, fences, walls, and sometimes even a convenient network of exposed irrigation hoses.

It was also clear that in the pasture plot there was one side with higher Argentine ant numbers (apparent before baiting) and that the reinvasion of the plot was coming primarily from one direction. If an additional buffer zone of control had been undertaken out from the side of high abundance we suspect the plot could have remained largely ant-free for the summer.

Another finding from the pasture trial is that reinvasion appeared to be in stages, so rather than low numbers of ants beginning to forage through most of the plot, the numbers tended to build up in the immediate zone of reinvasion before the ants were detected further from the reinvasion edge. Again, we suspect the situation in residential and business areas will be different in that ant foragers can utilise fast-tracks to quickly access resources in the central parts of treated properties, and potentially move nests quickly into those areas to make the best use of the resources present.

6.3 Trials of granular insecticides on lawn and gardens

The results clearly indicate that Biforce, No Ants Ant Sand, and Ant Stop G were all effective at reducing ant activity in lawns and bark gardens. The ability for ants to recruit to baits at the centre of the plots was also reduced, particularly in the first week, but it was unclear whether that was a result of reduced ant populations immediately surrounding the small plots or an actual barrier effect.

In both the lawn and bark gardens, the granules work down to the soil beneath, but we suspect the ants themselves may often be moving above the soil and walking on the mulch or grass itself, thereby potentially minimising the effectiveness of the treatment at providing a barrier to movement. All the treatments in the bark gardens showed a rise in recruitment activity in the second week, but a decline again in the 4th week. One possible explanation for this is that the rainfall in that week meant the soil below the bark was too wet for the ants and they preferred to walk over the top of the bark mulch in that week, but that is largely conjecture.

Another issue for interpreting the results of the granule treatments is that we have assumed that recruitment to non-toxic bait was unlikely to occur while the treatments were effective as ants would not be able to return to nests outside the plots in good health. While this is likely to be true in the first week for the toxins involved (bifenthrin and chlorpyrifos), it might be possible that the effects of the toxin were delayed for a few hours in subsequent weeks and that some ants recruiting to the baits may have been fatally affected at some stage later in the day. We would therefore suggest that the trials may have underestimated the longer-term barrier effect of the granules.

There were no consistent differences in the performance of the three types of granules on lawn or bark gardens. They are quick to distribute on grass, gardens and soil, and maintaining a treatment zone around the perimeters of a property would be relatively easy. If the treatment strip was 2 m wide there would be a high likelihood ants would be moving on the soil at some point. More importantly, the treatment would also reduce the likelihood of Argentine ant nests establishing in the gardens around the perimeter in the first instance.

6.4 Trials of surface sprays on sealed and gravel surfaces

Biff Ant, Arilon, and Termidor were all highly effective at killing ants that crossed concrete, bitumen and gravel for the first week, but their efficacy began to decline in the second week. Rainfall in the second week probably increased the level of decline, but the rainfall experienced was not unusually heavy or prolonged and would be typical for New Zealand conditions. The efficacy trial in the second week was started on the first clear morning after the rain and the concrete surface was visibly damp. This may have meant there was a slight film of water over the surface that reduced the level of contact between ant feet and the insecticide molecules. This would provide some explanation why there was an increased rate of insecticidal activity on the concrete in the third week (after dry weather) for both Biff Ant and Arilon. However, previous trials with Biff Ant on concrete tiles has also indicated that there can be some recovery in its insecticidal activity following rain events if the tiles are exposed to more sunlight, as exposure to UV light releases additional bifenthrin molecules from the treatment's polymers.

Biff Ant had a faster activity on the ants than the other treatments and also appeared to maintain activity comparatively well on all three surface types over three weeks. Termidor had a somewhat slower activity rate than Biff Ant and appeared to degrade significantly on the bitumen, and less so on concrete, but was at least as good as Biff Ant on the gravel after 3 weeks. Arilon has the slowest activity rate of the three sprays, as expected by the chemistry and mode of action, but it did not appear to degrade as much as Termidor on the bitumen and concrete surfaces after 3 weeks.

The rate of mortality on the gravel was slower than concrete or bitumen, but this may have been a result of a different methodology for exposing ants to the treated gravel rather than a real difference caused by the surface itself. Although a piece of gravel was in the small pottle with the ants for 2 minutes it does not mean they were in contact with the gravel for the entire time, so they may not have had as much contact with insecticide. This would explain both the slower rates of mortality and also help explain the relatively poor performance of Arilon on the gravel.

The longevity of the spray treatments was lowest on the bitumen surface, and all 3 insecticides appeared to degrade significantly after 3 weeks on that surface. More than 60% of ants still survived 48 hours after exposure to either the Arilon or Biff Ant surface, but Termidor appeared particularly degraded, with 95% of ants surviving.

It needs to be remembered that the trials with insecticides were specifically set up to look at their potential effectiveness when used to provide a barrier to reinvasion, and the results cannot be used to gauge their relative efficacy for control in the sense of reducing ant populations within a property. The reason for this is that the manufacturers of Arilon and Termidor both indicate that the insecticide can be carried on the bodies of the ants that cross a treated surface and spread around nest-mates through contact, potentially leading to nest destruction. We have not undertaken any independent research to test the relative efficacy of these surface treatments at providing population control in their own right or to test the extent to which there is within-nest transfer of the insecticide.

6.5 Potential alternatives for sustained ant control

The use of continued baiting to maintain low ant populations is one alternative to boundary control. It is generally suggested to repeat an application of Xstinguish several weeks after the initial treatment to mop up residual and rebounding colonies, but this is not a good method for longer term control because the field life of the Xstinguish bait is short so it would not necessarily be available to new invaders at the time they were breaching the boundaries. Xstinguish is also an expensive product and constant baiting using that product is unlikely to find favour with many residents.

Another potential approach that is worth testing is the use of affordable low-toxicity carbohydrate baits in bait stations placed around the perimeter of the property. The theory of low-toxicity baits is that the ants slowly accumulate a lethal level of insecticide throughout the colony and do not stop feeding on the bait as it is not associated with ill effects. This method has been used to achieve sustainable control of Argentine ants in citrus orchards overseas (Cooper et al. 2008) and could be adapted to a residential situation. Having bait stations constantly in place will begin to treat the ants very early in the reinvasion process and hopefully provide long-term control for individual properties where wide-scale treatment of the entire infestation is not occurring.

7. Conclusions

- In residential and commercial areas, there is a high risk of reinvasion by Argentine and Darwin's ants within a month of baiting, but the benefits of baiting can be prolonged by coordinating baiting amongst as many adjoining properties as possible, and this should include treatment of the street frontages.

- Reinvasion of Argentine ants into pasture baited in spring is slower than that of typical residential and commercial properties, probably due to lack of fast-track surfaces for ants to move along, but it is also strongly influenced by the density of ant populations adjoining the treated area.

- The use of granular insecticides such as Biforce, Non Ants Ant Sand, and Ant Stop G, do have a significant effect on ant populations in gardens and lawns, but it is unclear how effective they are at providing a true barrier to reinvasion, as ants could move above the soil layer on bark gardens or grassed areas.

- The granular insecticides are easy to apply, and a treatment band of about 2 m wide along a boundary garden or lawn should provide a buffer to rapid reinvasion, but will need to be re-applied every couple of months. This needs to be considered against the potentially negative environmental effects of sustained insecticide use.

- Biff Ant, Termidor, and Arilon were all very effective at killing ants that crossed treated areas of concrete, bitumen and gravel for at least a week, but their performance deteriorated variably depending on the surface type and rainfall. There was evidence that the effect of the treatments was negated when surfaces were damp.

- The performance of all the surface sprays deteriorated most quickly on bitumen. However, 3 weeks after treatment, none of the treatments achieved 100% mortality on any of the surfaces. Biff Ant was the most consistent of the treatments across all 3 surfaces over three weeks.

- The use of bait stations with long-lasting, low-toxicity carbohydrate bait should be investigated as a method for providing long-term control of Argentine and Darwin's ants on residential properties.

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