PERFORMANCE OF GOLIATH COCKROACH GEL AGAINST GERMAN COCKROACH (BLATTODEA: BLATTELLIDAE) AND A MIXED POPULATION OF AMERICAN COCKROACH AND AUSTRALIAN COCKROACH (BLATTODEA: BLATTIDAE) IN THE FIELD

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Abstract - Field studies were conducted to compare the performance of Goliath® Cockroach Gel (fipronil) and a spray treatment of Cislin Residual Insecticide® (deltamethrin). These were carried out in Sydney, NSW, Australia against *Blattella germanica* (L), and Townsville, Queensland, against a mixed population of *Periplaneta americana* (L.) and *Periplaneta australasiae* (L). In both studies fipronil (0.05% AI) was applied at two rates. For the German cockroach study the application rate was 1 spot (0.03 g) per m^2 and 3 spots (each 0.03 g) per m^2. For the American cockroach study the application rate was 1 and 3 spots (each 0.06 g) per m^2. The deltamethrin (10 g/l) was applied as a crack and crevice and surface spray treatment. (0.03% AI as a prepared spray). In Sydney there were 10 domestic properties with medium to heavy infestations in each treatment. The duration of the study was 12 weeks and post treatment assessments were made at 3 days, 1 week, 4, 8 and 12 weeks. In Townsville, there were 5 domestic properties in each of the gel treatments and 10 treatments properties treated with deltamethrin treatments. The duration of the study was also 12 weeks. Post treatment assessments were made at 2 and 6 weeks and 12 weeks. Both rates of fipronil gave a similar performance to deltamethrin at the early assessments and were superior at the 4, 8 and 12 weeks. At 12 weeks, the high rate of fipronil achieved a 99% percentage reduction, the low rate a 94.8%, and the deltamethrin spray treatment achieved a percentage reduction of 79.6%. Against a mixed population of American and Australian cockroaches all three treatments achieved control, with both rates of fipronil giving similar results to the deltamethrin spray treatment. At 12 weeks, fipronil at the high rate (3 x 0.06 g/m^2) achieved 97.8% reduction, deltamethrin spray achieved 88.4% reduction and fipronil at the low rate (1 x 0.06 g/m^2) achieved 76.1%.
Key words - *Blattella germanica, Periplaneta americana, Periplaneta australasiae*

INTRODUCTION

German cockroach *Blattella germanica* (L.), American cockroach *Periplaneta americana* (L.), and Australian cockroach *Periplaneta australasiae* (Fabricius) are widespread domiciliary pests in Australia (Neumann, 1991). American and Australian cockroach are more common in the northern tropical and subtropical regions where, because of the high relative humidity and temperature, they can be major pests in and around houses (Gerozisis and Hadlington, 1995).

Insecticide formulations which can be mixed with water and applied as a spray have been the most popular formulations for cockroach control (Mallis, 1990). Type II synthetic pyrethroids have been used widely for cockroach control because of their good residual life and flushing ability (Wickham, 1988). Deltamethrin, which is the subject of this study, is one of the most active of the pyrethroids and has been used extensively in Australia since the mid 1980’s.

Baits are starting to gain wide acceptance in the management of cockroaches (Reierson, 1995). Gel bait formulation may be more effective than dry baits (Denzer *et al.*, 1988). These gel baits have the added advantage that they can be placed out in small amounts in numerous locations and this can also improve bait efficiency (Bennett *et al.*, 1984). Traditional insecticides have not always been effective as baits and this may be in part due to their inherent repellency (Ebeling *et al.*, 1967). A range of new actives such as hydramethylnon, abamectin and sulphuramid have been incorporated into baits. These ingredients are less repellent, slow acting and can have a secondary kill effect due to coprophagy (Silverman *et al.*, 1991).

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More recently fipronil has been formulated as a cockroach control bait (Kaakeh *et al.*, 1997). Fipronil belongs to a new group of insecticides the phenylpyrazoles (Gant *et al.*, 1990; Cole *et al.*, 1993). Cross resistance to other insecticide groups has been shown to be at low levels (Scott and Wen, 1997). Baits incorporating this insecticide groups raises the possibility of their integration into cockroach management programs alongside the standard pyrethroid sprays. If comparable control standards can be achieved alternating control strategies can be initiated to manage resistance (Tabashnik, 1989) and provide enhanced control. In this study the effectiveness of two rates of fipronil gel are compared to a conventional spray formulation of deltamethrin in domestic situations.

MATERIALS AND METHODS

Insecticides, study sites and trapping

The insecticides investigated in this study were fipronil (Goliath® Cockroach Gel 0.5 g/kg, Rhone Poulenc) and deltamethrin (Cislin Residual Insecticide® 10 g/l, AgrEvo).

The German cockroach study commenced in the March of 1997 in Sydney, NSW, Australia and lasted for 12 weeks. The studies were carried out in government housing and apartments in the inner city. These are high density dwellings which are not regularly treated for cockroach infestations and have higher than normal German cockroach populations. The method used was the same as that used in an earlier study (Miller *et al.*, 1996). Populations were monitored using sticky traps (Zoro Zoro® brand, Taisho Pharmaceutical Company, Japan) (21cm x 9.5cm). For each pre and post treatment assessment, one half trap was placed for two nights at each of the following four locations in the kitchen: under the refrigerator, by the stove, under the sink and on the kitchen bench.

In the German cockroach study, post treatment assessments were made at 3 days, 1 week, 4 weeks, 8 weeks and 12 weeks. The American and Australian cockroach study was commenced in April 1997 in Townsville, Queensland, Australia and lasted 12 weeks. The study was carried out in single family homes or apartments. American and Australian cockroach populations were assessed by means of 500 ml glass food jars. The top one-third to one-half of the inner surface of the jar was coated with petroleum jelly to prevent the cockroaches escaping. The jars were baited with an attractant consisting of bread moistened with beer. Cockroaches trapped in the jars were returned into the same area.

At each domestic site 5 jars were left out for a period of two nights. Jars were placed in the kitchen by the stove, by the refrigerator, in the cupboard under the sink and by the rubbish bin; and in the bathroom and/or laundry areas and by hot water heaters. The location of all the jars at the pre-assessment and post treatment assessment were the same. In the American and Australian cockroach study the assessments were at 2 weeks, 6 weeks and 12 weeks after treatment.

Trap catch data were converted to percentage reduction for each dwelling:

$$\%\ \text{reduction} = \frac{(\text{number trapped before treatment - number trapped after treatment})}{\text{number trapped before treatment}} \times 100$$

The properties were treated by a licensed and experienced pest control operator under supervision of the authors. The deltamethrin was diluted with tap water and was applied as a spray with 0.03% AI. The pest control operator used a 8 litre compressed air hand-held sprayer (Rega Pumps, Garrard's Pesticides Pty. Ltd., Lawnton, Queensland, Australia) fitted with Spraying Systems® number 6 adjustable nozzle (Spraying Systems, Wheaton, Illinois, USA). A standard crack and crevice and surface spray pest control treatment was carried out in the kitchen, bathroom and laundry. The bedrooms and lounge room were usually not treated. However, the home owner was consulted about any other areas where cockroaches were a particular problem and these were treated if thought to be a significant breeding area. Between 2-4 litres of diluted spray were applied per property depending on property size. Areas which could not be sprayed such as refrigerator motors and electrical equipment were given

Table 1. Gel placements.

Typical treatment areas	Gel low rate ($1 \times 0.03 g/m^2$)	Gel high rate ($3 \times 0.03 g/m^2$)
Refrigerator	3	9
Stove	2	6
Single cupboard	2	6
Double cupboard	4	12
Fixture/s	1	3
Drawers	1	3

Table 2. Study treatment, application rates and replication in the German cockroach - Study 1, and American and Australian cockroach - Study 2.

Time period	Product	Application rate	Number of replicates (dwellings)
Study 1 **German cockroach**			
	Goliath cockroach gel® fipronil (0.5 g/kg)	low rate 1×0.03 g/m²	10
March to June 1997	Goliath cockroach gel® fipronil (0.5 g/kg)	high rate 3×0.03 g/m²	10
	Cislin Residual Insecticide® (deltamethrin 10g/l)	0.03% ai.	10
	Control	untreated	10
Study 2 **American/Australian cockroach**			
	Goliath cockroach gel® fipronil (0.5 g/kg)	low rate 1×0.63 g/m²	5
April to July 1997	Goliath cockroach gel® fipronil (0.5 g/kg)	high rate 3×0.03 g/m²	5
	Cislin Residual Insecticide® (deltamethrin 10 g/l)	0.03% ai.	10
	Control	untreated	5

a light treatment of Coopex® Insecticidal Dusting Powder (10 g/kg permethrin) using a small hand duster.

Gels were applied by a licensed pest control operator using gel gun fitted with a metal nozzle. In the German cockroach study the gel was applied at two rates, 1×0.03 g/m^2 (low) and 3×0.03 g/m^2 (high). In the American and Australian cockroach study the gel was also applied at two rates but the spot size was larger, 0.06g. The two rates were 1×0.6 g/m^2 (low) and 3×0.06 g/m^2(high). The surface area measurement was based on surface area of cupboard or appliance, not floor area. The rate was achieved by varying the spot size and the spot size which approximated to 0.03 g and 0.06 g was determined in the laboratory prior to the field application. Typical gel placement locations are included: fridge, stove, under sink, on bench under or by microwave or toaster, lower kitchen cupboards, upper kitchen cupboards, by rubbish bin, bathroom, toilet, laundry, and by hot water service. For a consistent field application rate gel spots were placed following the guidelines on quantities and locations listed in Table 1. Kitchen cupboards were not emptied for gel applications.

During the pest control treatment properties were assessed on their state of sanitation. The properties were placed into three categories:

G	Good Standard	Good sanitation level i.e., floor and kitchen benches clean - no residual foodand grease.
M	Medium Standard	Medium sanitation level. Some dirt on floor and food scraps present.
P	Poor Standard	Poor sanitation level. Dirt and grease on floors and benches, food scraps present, open garbage containers, unwashed plates and utensils. Often moisture present from dripping taps and leaking refrigerators.

This sanitation assessment was carried out to ensure that no treatment had a very high number of properties with poor sanitation and also to see if there was a correlation between any control breakdown and poor sanitation.

Data analysis

The treatments and replication for the two studies are detailed in Table 2. A Kruskal-Wallis test was used to determine if there was any significant differences between pre-assessment levels in the various treatments and control groups (Walpole, 1982). After the pre-treatment assessment count, properties were assigned to particular treatments so that the distribution of initial population sizes was equivalent among the treatments. Wilcoxon matched pairs signed ranks tests were used to show if the differences between pre-assessment and post treatment numbers were significantly different. Among the active treatments Wilcoxon rank sum tests were used to detect differences between the treatments.

RESULTS

German Cockroach Study

The German cockroach study consisted of four treatments (control, fipronil gel at high and low rates, and deltamethrin spray) each applied to ten dwellings, with effects on populations of German cockroaches recorded after three days, 1 week, 4 weeks, 8 weeks, and 12 weeks. Figure 1 summarises the percentage reduction in the cockroach populations at various times for the insecticide treated and untreated dwellings.

The infestation levels of the 40 dwellings were assessed before any treatment (the pre-assessment). The pre-assessment numbers varied from 12 to 263 cockroaches per property. A Kruskal-Wallis test showed that there were no significant differences ($p > 0.5$) between the pre-assessment levels in the dwellings assigned to the four different treatments.

Control populations showed some fluctuations during the study (-20.8% to 22.7%). Wilcoxon matched pairs signed ranks tests showed that there were no significant differences between the pre assessment level and the infestation levels at any of the other time periods in the controls ($p > 0.5$ in each case).

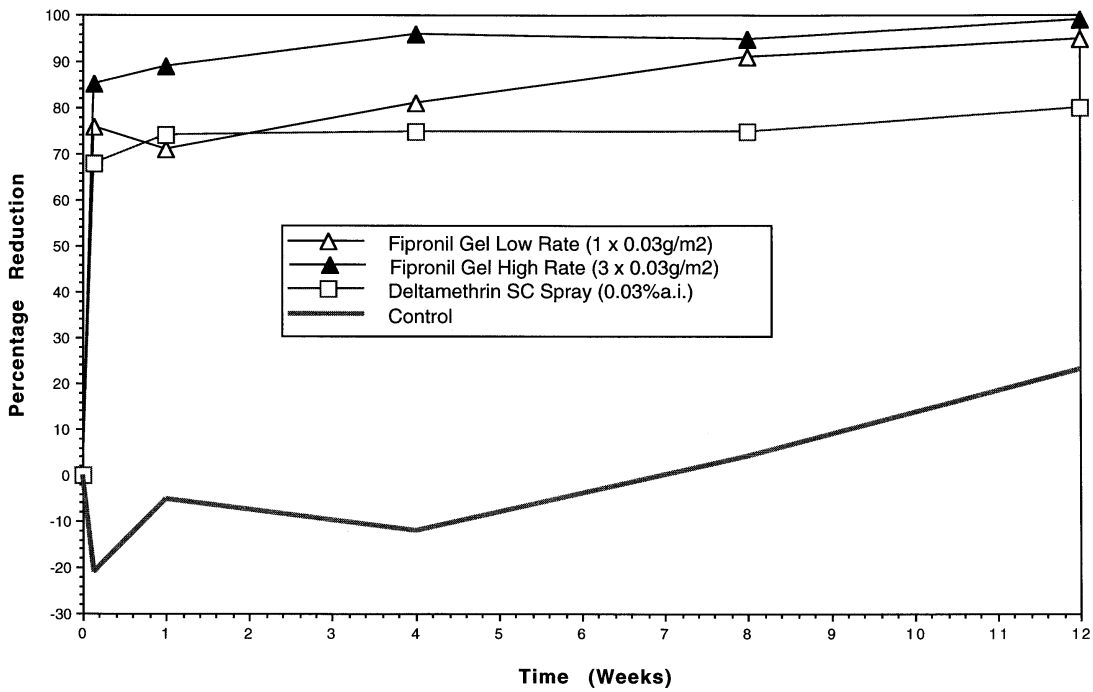

Figure 1. The percentage reduction of German cockroaches

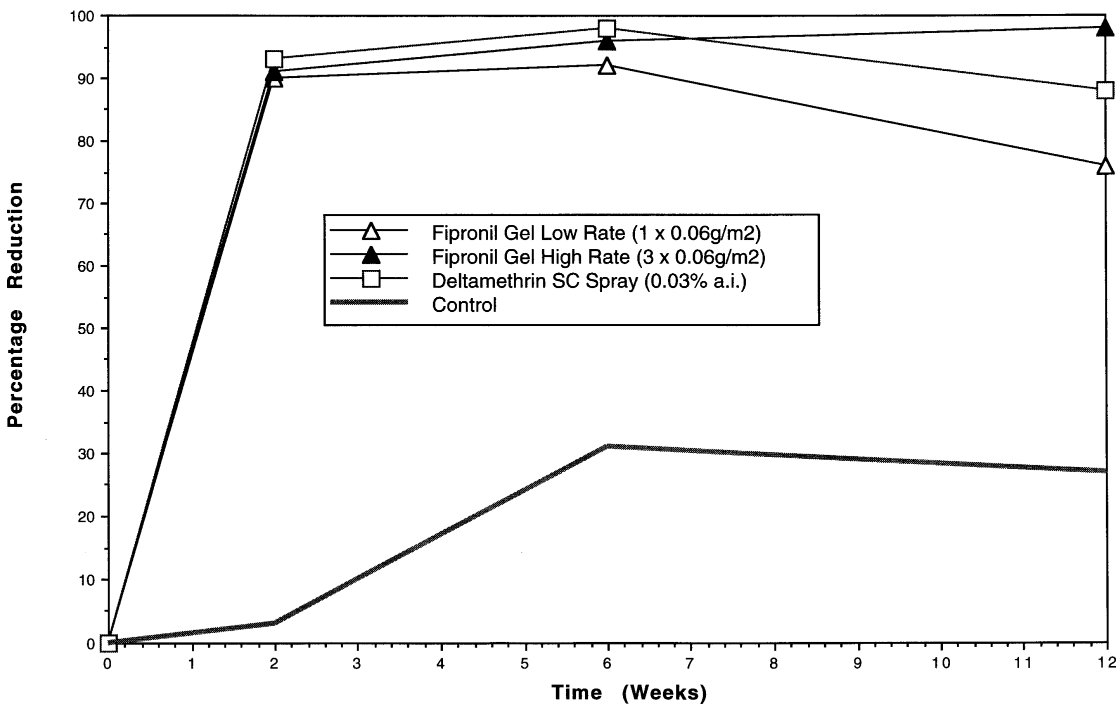

Figure 2. The percentage reduction of American and Australian cockroaches

At 3 days post treatment, deltamethrin and fipronil low achieved similar population reductions (68.1% and 75.7% respectively) and the fipronil high gave 85.3% reduction. The deltamethrin percentage reduction gradually improved to 79.6% reduction at 12 weeks. Fipronil low and fipronil high achieved 94.8% and 99.0% reduction respectively at 12 weeks. The three active treatment groups (fipronil high, fipronil low, and deltamethrin) showed a significant reduction on their respective pre-assessment levels at all time periods. The significance levels were $p < 0.1$ for thirteen matched pairs sign tests, and ($p < 0.5$) for two matched pairs sign tests (fipronil at the low rate at 1 week and 4 weeks).

Among the active treatment groups, ten Wilcoxon rank sum tests were run to detect differences between fipronil and deltamethrin. Fipronil high performed significantly better than deltamethrin at the 4 weeks ($p < 0.5$), 8 weeks ($p < 0.5$), and 12 weeks ($p < 0.1$) assessments while there was no significant difference between the two at the 3 day and 1 week assessments ($p > 0.5$ in each case).

Fipronil low performed significantly better than deltamethrin at 8 weeks ($p < 0.5$) and 12 weeks ($p < 0.5$) assessments, while there was no significant difference between the two at the 3 day, 1 week, and 4 weeks assessments ($p > 0.5$ in each case). In summary, all three active treatments seemed effective at all assessment periods and both fipronil rates performed better than deltamethrin at the long term assessments.

American and Australian Cockroach Study

Figure 2 summarises the percentage reduction in the cockroach populations at various times for the insecticide treated and untreated dwellings. The infestation levels of the 25 dwellings were assessed before any treatment (the pre-assessment). The pre-assessment levels varied from 6.5 to 263 cockroaches per property. A Kruskal-Wallis test showed that there were no significant differences ($p > 0.5$) between the pre-assessment levels in the dwellings assigned to the four different treatments.

Control populations remained fairly steady through the study but there was a slight reduction (26.7%) at the 12 week assessment. For the control group, Wilcoxon matched pairs signed ranks tests showed that there were no significant differences between the pre-assessment level and the infestation levels at the other time periods ($p > 0.5$ in two cases) except for the 12 weeks assessment which showed a significant reduction ($p < 0.5$).

At all assessments the three active treatment groups (fipronil high, fipronil low, and deltamethrin) showed a significant reduction on their respective pre-assessment levels. At 2 weeks post treatment the percentage reductions for all treatments were similar. For the fipronil high and low rate the reductions were 90.6% and 89.9% and in the detramethrin treatments was 93.4%. At 12 weeks post treatment the percentage reduction achieved by fipronil gel at the high and low rates were 97.8% and 76.1%. Deltamethrin achieved a percentage reduction of 88.4% at this time. The significant differences were ($p < 0.5$) for six matched pairs sign tests (fipronil) and ($p < 0.1$) for three matched pairs sign tests (deltamethrin). The difference in significance level reflects the greater power available for the Cislin tests because of the larger sample size.

Among the active treatment effects three Wilcoxon rank sum tests were run to detect differences in performance. They compared the fipronil high and fipronil low rates at the three assessments. No significant differences were found ($p > 0.5$ in each case). Next the results were pooled and three further rank sum tests were run to compare fipronil and deltamethrin at each time period. Again no differences were found ($p > 0.5$). In summary, all active treatments were effective at all assessment periods and there were no significant differences detected between them.

DISCUSSION

Resistance to pyrethroids has been noted in some countries (Atkinson *et al.*, 1991; Jensen, 1993), but only isolated cases have been reported in Australia (Horwood *et al.,* 1991) and this was in commercial premises with extended pyrethroid use. The mode of action of pyrethroids and fipronil are different (Umeda *et al.*, 1988; Cole *et al.*, 1993) and thus fipronil has potential for use in the management of bio-

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Wm H. Robinson, F. Rettich and G.W. Rambo (editors). 1999.

chemical resistance to pyrethroids, and vice versa. Where baits have been used over extended periods against other animals, such as rodents, bait shyness has been noted (Meehan, 1984). Incipient behavioural resistance has been noted with baits (Silverman and Bieman, 1993) and cockroaches certainly can detect, and may be repelled by some insecticides (Ebeling *et al.*, 1967). Alternating two classes of insecticides has been proposed for managing pyrethroid resistance in German cockroach (Cochran, 1990). Combination or alternating use of pyrethroid sprays and fipronil baits present possibilities in terms of managing both behavioural and biochemical resistance because of the differing way that cockroaches contact spray deposits and baits, and the different biochemical targets of pyrethroids and fipronil. Future laboratory and field studies should investigate the potential of these combinations.

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