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Development of Fipronil Gel Bait Against German Cockroaches, *Blattella germanica* (Dictyoptera: Blattellidae): Laboratory and Field Performance in Bandung, Indonesia

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ABSTRACT

The present study was conducted with the aim to develop an easily made fipronil insecticidal gel and test this gel both in the laboratory and in the field. Four gel baits were developed, each having the same amount of fipronil (0.03%) but with different attractants. The attractants were: chicken liver, honey-banana, cow blood and cockroach feces. Laboratory tests showed that 100% mortality was achieved within 36 h with chicken liver, 48 h with honey-banana, 60 h with cow blood and 72 h with cockroach feces, respectively. Statistically, there were no difference between the use of honey-banana and chicken liver as compared to the remaining two. The next test showed that bait containing honey-banana was the most stable gel in terms of consistency and texture. Field trials using honey-banana containing bait was conducted in 16 kitchens, with 2 controls. Throughout the five week trials, the controls received weekly insecticide spraying treatment using cypermethrin. The results showed that the bait was very effective in controlling the population of German cockroach, >90% reduction was achieved after 2 weeks of treatment and 100% reduction was achieved after 5 weeks of treatment, with the initial number of cockroach per kitchen ranging from 41-243.

Key words: *Blattela germanica*, gel bait, attractant, fipronil

INTRODUCTION

The German cockroach, *Blatella germanica* is a cosmopolitan pest and considered as the most significant urban insect pest. In Indonesia and in many parts of the world this pest has been regularly controlled by insecticides. However, the intensive and continuous use of insecticides to control this cockroach has caused the development of resistance of cockroach to several major group of insecticides (Lee *et al.*, 1996; Ahmad *et al.*, 2009) and hinders the control programs, causing cockroaches continue to infest urban environments. Ongoing investigations in our laboratory (unpublished data) have shown that German cockroaches collected from Jakarta showed very high resistance to pyrethroid with a Resistance Ratio (RR_{50}) of 1000-fold to permethrin as compared to the susceptible strain.

Due to the resistance to insecticides and environmental concerns, gel baits containing relatively new insecticides such as hydramethylnon, fipronil, abamectin and imidacloprid, have been widely used to control German cockroaches in the US for the past 10-13 years (Appel and Tanley, 2000;

Wang *et al.*, 2004) and recently in some other countries such as Malaysia and Korea (Sulaiman *et al.*, 2007). Field trials of commercial baits show that most bait are equally effective against susceptible cockroaches. For example, Ree *et al.* (2006), reported that using fipronil bait stations in several restaurants in Seoul Korea got 93.9% overall average of the cockroach reduction after 4 weeks of the treatment. In Indonesia, due to their expensive price, the use of gel baits to control cockroaches have not been widely used and only two brands are available in the market i.e., optiguard (Emamektin benzoat: 0.102%) and goliath (fipronil 0.051%). Consequently, residual sprays using synthetic pyrethroids [despite the fact that the cockroaches have been developed resistance to pyrethroids (Ahmad *et al.*, 2009) remain to be the method of choice by Pest Management Professionals (PMP).

In experiments described here, we developed laboratory-made gel based bait in two steps, i.e., 1) Cockroach gel bait development with the emphasis on finding the most efficacious bait which contains 0.03% fipronil and attractant from different type of foods. 2) To determine the performance of a gel bait to control field populations of German cockroaches in kitchen restaurants in Bandung.

MATERIALS AND METHODS

The laboratory and field experiments were conducted from November 2008 until March 2009 in Bandung (06°54'S, 107°36'E, 768 m a.s.l), West Java, Indonesia.

Laboratory experiment

Cockroaches: The insecticide-susceptibe strain of *Blatella germanica* was used in the experiments; they were obtained from VCRU (Vector Control Research Unit) Universiti Sains Malaysia and reared in our laboratory since 2007. Rearing and experimental conditions were; temperature of 22-28°C, relative humidity of 52-95% and photoperiod of 12: 12 and was provided with water and Purina cat food ad-libitum. Methods for rearing were essentially as described by Noland *et al.* (1949).

Chemicals: The insecticide used in the gel was Fipronil 89.8% [Active Ingredients (AI)] obtained from Bayer Indonesia. Fipronil was dissolved and diluted in acetone for use in the experiment.

Gel baits: The gel (Table 1) was prepared as follows: Water, gelling agent (polyacrylate), carragenan and cane sugar were poured into a mixer and then slowly mixed until the components were dissolved. Then dimethyl sulfoxide, biocide (proxel GXL), attractant, propylene glycol, sorbitol and fipronil were added and stirred until homogenous gel was obtained. This basic recipe was modified in accordance with the designated gel, either chicken liver, cow blood, cockroach feces or honey-banana gels.

Laboratory experiment: For each treatment with five replications, ten adult cockroaches were placed in an arena (36 by 26 by 12 cm) for four days before bait introduction. To prevent escapes, the upper portion of the inner arena was greased with Vaseline. Each arena received Purina cat food and water *ad libitum*. After four days, bait was placed in each arena, except in the control arenas. Mortality of the cockroach was recorded every 12 h for up to 96 h.

Table 1: Composition of gel for *Blattella germanica* bait (all amounts given as % by weight)

Components	Chicken liver gel	Cow blood gel	Cockroach feces gel	Honey-banana gel
Fipronil	0.03	0.03	0.03	0.03
Gelling agent	0.75	0.75	0.75	0.75
Cane sugar	30	30	30	30
Carrageenan	2	2	2	2
Dimethyl sulfoxide	0.05	0.05	0.05	0.05
Chicken liver powder attractant	5	-	-	-
Cow blood powder attractant	-	5	-	-
Cockroach feces powder attractant	-	-	5	-
Honey-banana food scent attractant	-	-	-	5
Biocide	0.5			
Propylene glycol	5			
Sorbitol (70% w/w)	10			
Water	53.33	53.33	53.33	53.33

Field experiment

Study area: A total of eighteen kitchen restaurants in Bandung areas. These kitchens had received pyrethroid regular spray to control *Blatella germanica* by pest management professional over a period of 2 years. During the study period all insecticide spraying were stopped except in the controls.

Density of pre and post-treatment: pre-and post treatment density was assessed by visual count. Methods for visual count were essential as described by Agrawal and Tilak (2006). Briefly, the visual counts were carried out in the morning at 0800-0900 h when the kitchen was still closed and dark. The dark kitchens were entered quietly and then the lights were turned on and the cockroaches were counted as they ran for 5 min. Density of pre-treatment was conducted one time in each kitchen, while post-treatment were conducted every week for up to five weeks.

Bait application: The best bait developed from the laboratory experiment (0.03% Fipronil and 5% honey-banana food scent) was used in the field trials. The bait was applied using an applicator in each kitchen (kitchens were 15 m^2 in size on average) and each kitchen was treated with 20 g of gel bait. Sixteen kitchens were treated with baits and 2 kitchens were untreated controls. Post-treatment evaluation was made visually every week for up to five weeks as described above and the percentage of reduction was calculated using the formula developed by Mulla *et al.* (1971):

$$\% \text{ reduction} = \left[100-\left(\frac{C1}{T1}\times\frac{T2}{C2}\right)\times 100\right]$$

Where:
C1 = No. of cockroaches in untreated controls before treatment
T1 = No. of cockroaches before the treatment
C2 = No. of cockroaches in untreated controls after treatment
T2 = No. of cockroaches after treatment

RESULTS AND DISCUSSION

Laboratory experiment: Gel bait efficacy in the laboratory showed that all formulations were able to kill 100% of the laboratory cockroaches after 72 h. Furthermore, as can be seen in Table 2,

Table 2: Mortality response of *Blattella germanica* with respect to gel baits containing fipronil and one of four attractants

Attractant	Mortality
Control	0.00±0.00[a]
Cow blood	85.31±18.67[b]
Cockroach feces	86.88±17.12[b]
Honey-banana	97.19±10.85[c]
Chicken-liver	97.81±6.08[c]

N = 32 for each treatment, average number of mortality in the same column followed by the same superscripts are not significantly different (ANOVA followed by Duncan's test, $p<0.05$)

Table 3: Estimated number of *Blattella germanica* in each kitchen (A1 through A16) based on visual count before and after the treatment

	No. of cockroach																	
	Kitchen																Kitchen (Control)	
Duration	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	A13	A14	A15	A16	K1	K2
Before treatment	103	85	51	145	150	65	43	102	154	192	217	51	230	243	73	41	89	74
After treatment (week)																		
1	5	15	1	6	13	17	0	28	30	58	25	15	75	42	27	24	82	65
2	0	2	0	2	3	0	0	0	7	22	11	4	30	23	3	6	92	58
3	0	1	0	0	1	0	0	0	1	3	7	0	25	3	0	2	34	18
4	0	0	0	0	0	0	0	0	3	1	0	0	7	0	0	0	56	26
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	49	43

A total of sixteen kitchens, designated A1 through A16 and two kitchens as controls designated K1 and K2 were utilized in these studies

gel baits containing either chicken liver or honey-banana food scent were significantly better (> 97% mortality) as compared to the cockroach feces or cow blood containing gels (85.3 and 86.9% mortality, respectively).

Based on this finding coupled with our observation, the gel containing honey-banana, remained soft and palatable after four weeks, if compared to the other formulations which were a bit hard and less palatable. We decided to use honey-banana food scent (5%) as the attractant for the gel bait to be used in the field trials.

Field trials: Before and after treatment, visual counts of cockroaches from all kitchens are shown in Table 3. It shows that all 18 kitchens had moderate to heavy infestations with the number of cockroaches found ranging from 41-243. It also shows that after only 1 week of treatment, no cockroaches were found in kitchen A7, but remained high in kitchen A13. After four weeks, 13 out of 16 kitchens were free of cockroaches and after 5 weeks, no cockroaches were seen during the inspection, while controls remained high throughout the experimental period.

Table 4 shows that in general, baiting with fipronil insecticide is very effective in reducing the number of cockroaches in all kitchens; the reduction rates ranging from 76.7% in the first week and >90% after 2-4 weeks and reached 100% after 5 weeks of to the controls.

Even though we did not measure the amount of food eaten nor did we conduct olfactory meter assays, the results in the laboratory experiment suggest that all gel baits were highly attractive as compared to the cat food. The fact that all bait formulations used in this experiment were

Table 4: Reduction rate of *Blattella germanica* with bait application at different kitchens (A1 through A16) in Bandung

	Reduction rate (%) of cockroach with bait application as compared with control 1					Reduction rate (%) of cockroach with bait application as compared with control 2				
	Week after treatment					Week after treatment				
Kitchen	1	2	3	4	5	1	2	3	4	5
A1	94.7	100	100	100	100	94.5	100	100	100	100
A2	80.8	97.7	96.9	100	100	79.9	97	95.2	100	100
A3	97.9	100	100	100	100	97.8	100	100	100	100
A4	95.5	98.7	100	100	100	95.3	98.2	100	100	100
A5	90.6	98.1	98.3	100	100	90.1	97.4	97.3	100	100
A6	71.6	100	100	100	100	70.2	100	100	100	100
A7	100	100	100	100	100	100	100	100	100	100
A8	70.2	100	100	100	100	68.7	100	100	100	100
A9	78.9	95.6	98.3	96.9	100	77.8	94.2	97.3	94.5	100
A10	67.2	88.9	95.9	99.2	100	65.6	85.4	93.6	98.5	100
A11	87.5	95.1	91.6	100	100	86.9	93.5	86.7	100	100
A12	68.1	92.4	100	100	100	66.5	90	100	100	100
A13	64.6	87.4	71.5	95.2	100	62.9	83.4	55.3	91.3	100
A14	81.2	90.8	96.8	100	100	80.3	87.9	94.9	100	100
A15	59.9	96	100	100	100	57.9	94.8	100	100	100
A16	36.5	85.8	87.2	100	100	33.4	81.3	79.9	100	100
Aver.	77.8	95.4	96	99.5	100	76.7	93.9	93.8	99	100

apparently more attractive to cockroaches than the cat food is rather surprising, even though the experiment was not able to clearly show which food element that might contribute to the attractiveness of the bait. It is possible that the combination of fructose and one of four attractants, i.e., honey-banana food scent, cockroach feces, chicken liver and cow blood in the gel bait which contained 44.5% water by weight provides a very good combination of highly attractive formulation to the cockroach. Sugars are known as phagostimulants to many insects including cockroaches (Bernays, 1985). Among them, fructose for example, was shown to stimulate feeding of Jwax strain German cockroaches (Wang *et al*., 2004). It is apparently the reason why some commercial cockroach baits contain fructose. Even though we did not use any commercial lures available for cockroach such as Trapper, Victor pheromone and food lures, or the GP-2 tablet (Nalyanya and Schal, 2001), present findings suggest that nonproprietary attractants used in this experiment might have been as good as the proprietary ones. In this experiment, it is interesting to note that for unknown reasons, gel baits containing either honey-banana food scent or chicken liver as attractant provided higher mortality, which suggest that more gel baits were eaten, than those baits containing cow blood or cockroach feces.

It has to be mentioned here that in the field trial, throughout the experiment, the controls (two kitchens) were regularly sprayed with insecticides by the PMP, which suggested that the cockroaches in the control kitchens had already developed resistance to insecticide. This finding is rather surprising and one can expect that the population would have been higher had no spraying in the control was performed by the PMP. Based on the information obtained from the PMP, they used cypermethrin to control the cockroaches in the premises. Even though we did not do the resistance test, we suspect that the population of cockroach in all kitchens had developed resistance

to cypermethrin (suggested by the fact that all kitchens had regularly sprayed, but all insecticide spraying were stopped during the experimental period except in the controls). In Indonesia, heavy resistance to pyrethroids has been reported by Ahmad *et al.* (2009) and recently in our Laboratory (unpublished), our data shows that some German cockroaches collected from several restaurants in Jakarta had developed heavy resistance to pyrethroid with resistance ratio up to 1000 times to permethrin. The magnitude of resistance to permethrin in Indonesia is very alarming and needs further actions, among others by not using pyrethroid anymore. In other countries, Iran for example, even though Nasirian *et al.* (2009) found that all field strains was resistance to permethrin with the resistance ratios of 3.6 to 26.1. These ratios are considerably lower as compared to those in Indonesia (up to 1000 times to permethrin).

Overall, the result of this study shows that the application of insecticidal bait, in this case using fipronil as insecticide was able to control German cockroaches very effectively. This finding is very encouraging knowing the fact that our bait(s) which was developed using our own recipe, which contained gel, water, fructose, honey-banana food scent and fipronil 0.03% worked extremely well and apparently, their efficacy in controlling cockroaches are comparable to the commercial ones. In addition, since the mode of action of fipronil is different than pyrethroid, fipronil has potential for use in the management of cockroach resistance to pyrethroid (Miller and Peters, 1999). Present findings support those of Nasirian *et al.* (2006) who reported that fipronil was very effective against field population of German cockroaches.

Moreover, even though the bait developed here was very effective, it is important to note that in some countries, resistance to gel baits has been reported. For example in USA, Cincy strain of *B. germanica* was highly resistance to two commercially available gels, i.e., Avert® and Maxforce® and the resistance was due to behavioral rather than physiological in nature as suggested by no feeding at all or a much reduced feeding response to both Avert® and Maxforce® as compared with laboratory nonaverse strains (Wang *et al.,* 2004). To see whether bait aversion is also developed in *B. germanica* in Indonesia, more tests with different strains and different food ingredients of the gel are desirable.

During the trial, we were also able to confirm our previous assumption that the PMP who conducted the cockroach control in the premises did not understand that the cockroaches that they were dealing with had apparently developed resistance to insecticides cypermethrin, as showed by treatment failure in the controls (the controls were sprayed on a weekly basis throughout the trials). Therefore, this study recommends the need of good understanding about Integrated Pest Management concept for PMPs as well as their understanding about insect resistance to insecticides, bait aversion phenomenon and ways to manage them.

In conclusion, we demonstrated that fipronil-carbohydrate (fructose and honey-banana food scent) based gel were highly effective to control German cockroaches in the field. And their efficacy in controlling cockroaches is comparable to the commercial baits.

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