

# Efficacy of imidacloprid and fipronil gels over synthetic pyrethroid and propoxur aerosols in control of German cockroaches (Dictyoptera: Blatellidae)

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## Abstract

**Background & objectives:** Resistance amongst cockroaches has been reported to most of the spray insecticides apart from the problem of food contamination and inconvenience. Gel baits which can be selectively applied have been found effective in control of cockroaches in laboratory studies but very few field studies are available. This trial was planned to evaluate the efficacy of fipronil (0.01%) and imidacloprid (2.15%) gels over synthetic pyrethroid (0.02% deltamethrin + 0.13% allethrin) and propoxur (2%) aerosols in control of cockroaches in the field.

**Methods:** Survey was done to find out pre-treatment density in catering establishments and houses by visual count and sticky trap methods. A total of 10 catering establishments and 10 houses having high cockroach infestation were selected by sampling (two catering establishments and houses for each insecticidal treatment and two for control). Propoxur and synthetic pyrethroid aerosols were used for spraying the infested sites once only. Single application of fipronil and imidacloprid gels was used as crack and crevice treatment. Visual count method gave better indications of cockroach infestation as compared to sticky trap method, hence, the same was followed for post-treatment evaluation every week up to 12 weeks.

**Results:** Synthetic pyrethroid could not bring about the desired reduction in cockroach infestation in the present study. Single application of fipronil gel was able to reduce cockroach infestation up to 96.8% at the end of 12 weeks whereas imidacloprid application resulted in 90.9% reduction and propoxur resulted in 77.5%. However, propoxur was more effective in reducing the cockroach density by first week in comparison to imidacloprid and fipronil gels but its efficacy started declining after 8th week. Difference was found statistically significant by Kruskal-Wallis H-test.

**Conclusion:** The study reports the efficacy of propoxur aerosol, imidacloprid gel and fipronil gel baits for control of cockroaches.

**Key words** *Blattella germanica*; Imidacloprid and Fipronil gels; Propoxur; synthetic pyrethroid; aerosols

## Introduction

The cockroaches plague humans in homes, restaurants and any buildings where food is stored, prepared or served. Some people may become allergic to cockroaches after frequent exposure as it may cause allergic reactions, including dermatitis, itch-

ing, swelling of the eyelids and more serious respiratory conditions<sup>1</sup>. Cockroaches can sometimes play a role as carriers of intestinal diseases, such as diarrhoea, dysentery, typhoid and cholera<sup>2,3</sup>. Heavy infestations of cockroaches can be dealt with chemical control measures (residual spray, aerosol, dust, baits and gels), followed by environmental management

to deprive the insects of food and shelter<sup>4</sup>. The German cockroach is resistant to several organochlorine, organophosphorus, carbamate and pyrethroid insecticides<sup>5</sup>. In comparison to residual sprays against cockroaches, aerosol has been found more effective<sup>6</sup>. The aerosols have a better reach in the cracks and crevices, the usual harbourages for cockroaches than other spraying techniques.

The development of gel baits (fipronil and imidacloprid), which can be selectively applied where the cockroaches are living has changed the entire concept of cockroach control<sup>7</sup>. Baits offer the advantage of long-term residual activity, safe application technology, fast action and reduced odour when compared with residual sprays. In addition, baits have also been reported to possess secondary poisoning effect through necrophagy and coprophagy<sup>8</sup>. Imidacloprid is an insecticide belonging to the chloronicotinyl class of compounds and its use as a new crop protection agent was first proposed in 1991<sup>9</sup>. Because it exerts its effects after oral ingestion, imidacloprid is also suitable for use in bait formulations, and its use in cockroach control is seen as an important area of application<sup>10</sup>. Extensive laboratory and field studies have demonstrated the high efficacy of imidacloprid cockroach gel against economically important cockroach species. Fipronil, a phenylpyrazole insecticide was discovered by Rhone-Poulenc Agro in 1987, introduced in 1993, and registered as a pesticide in the U.S. in 1996<sup>11</sup>. Various studies have reported the efficacy of fipronil gel treatment over conventional insecticidal formulations in the control of cockroach infestation in cookhouses of urban households<sup>12,13</sup>. The present study was conducted with an aim of evaluating the new insecticidal formulations fipronil gel, imidacloprid gel and synthetic pyrethroid over propoxur in control of German cockroaches in catering establishments and houses.

### Material & Methods

*Study area:* The study was carried out in catering establishments and houses in a city of Uttar Pradesh. Catering establishments selected were large in area

(~1500 ft<sup>2</sup>) and were separated from each at a distance of 0.5 to 1 km. Each catering establishment was having kitchen, dining hall, pantry and ration store. Pooled data were used for each catering establishment and house after estimating cockroach density in kitchen, dining hall, pantry and ration store. Ten catering establishments and ten houses were selected for treatment and control by simple random sampling method.

*Test chemicals:* The insecticides evaluated were propoxur aerosol (2.0%), synthetic pyrethroid aerosol (0.02% deltamethrin + 0.13% allethrin), imidacloprid gel (2.15%), and fipronil gel (0.01%) obtained from open market as ready to use formulations. All insecticide compounds used as formulations are household insecticides and registered for use. Baseline information regarding susceptibility of cockroaches against tested chemicals in study area was not available as no similar study has been carried out earlier in this region.

*Trial procedure:* The trial was planned as a field study to evaluate the efficacy of the candidate insecticides in the control of cockroaches in catering establishments and houses. The study included the following:

*Complaints of residents regarding cockroach infestation:* The individuals whose catering establishments and houses were included in the study were briefed about the study to get their full cooperation and participation. Assurance of full participation was ensured before inclusion into the trial. They were given a proforma which included their subjective assessment of cockroach problem, importance they attach to control and control measures adopted. The response was high infestation (25 catering establishments and 34 houses), low infestation (3 catering establishments and 8 houses) or no cockroach (1 catering establishment and 4 houses) seen. Catering establishments and houses with high infestation were considered for inclusion in the trial.

*Pre-spray assessment in field:* In every catering establishment and house included in the study, follow-

ing pre-treatment assessment was done.

(i) *Visual counts*: The visual counts were done in the night after 2200 hrs. The participants whose catering establishments and houses were included in the study were asked to switch off the entire light by 2100 hrs. The lights were switched on after 2200 hrs and cockroaches were counted as they ran about hiding over tables, sink, cooking areas etc. Light from a torch was thrown behind cabinets, storage areas and dish racks for counting the cockroaches. A 5 min count of cockroaches was taken. This method has been used by most of the earlier workers. Catering establishments and houses having visual count more than 5 per 100 ft<sup>2</sup> were graded high infestation, 3–5 per 100 ft<sup>2</sup> medium infestation and less than 3 per 100 ft<sup>2</sup> as low infestations.

(ii) *Trap count*: Sticky cockroach traps were placed around the usual harborages of cockroaches. About 20–25 traps were placed to cover the suspected hiding sites in each catering establishment and house. Cockroach traps were removed next morning to estimate the density.

(iii) *Insecticidal spray*: Propoxur aerosol and synthetic pyrethroid aerosol available as pressurized cans were used for spraying the infested sites as well as potential harborage points once only in selected catering establishments and houses. Propoxur aerosol and synthetic pyrethroid aerosol were applied @ 100 ml/100 ft<sup>2</sup>. Single application of fipronil gel and imidacloprid gel was used as crack and crevice treatment. Using a Bait Gun, the imidacloprid and fipronil gels were applied in the form of spots 5 mm in diameter (~0.1 g gel). These were distributed in the infested area @ 2 linear spots per meter. No treatment or any cleanliness drive was undertaken in the control catering establishments and houses.

*Post-treatment density*: Post-treatment density was assessed by visual count method every week up to 12 weeks as it was found to be better indicator of cockroach infestation in comparison of sticky trap method. Sticky trap method was not used post treatment for

collection of cockroaches as it may also affect the results by acting as an intervention for cockroach control. The visual assessment data in treatment and control of catering establishments and houses were considered for computation of percent reduction of cockroach infestation in the respective catering establishments and houses. The percent reduction was calculated using Mulla's formula<sup>14</sup>— % reduction =  $100 - (C_1/T_1 \times T_2/C_2) \times 100$ . Where,  $C_1$  is the number of cockroaches in control catering establishments/houses pre-treatment;  $T_1$  is the number of cockroaches in treatment catering establishments/houses pre-treatment;  $C_2$  is the number of cockroaches in control catering establishments/houses post-treatment; and  $T_2$  is the number of cockroaches in treatment catering establishments/houses post-treatment. Kruskal-Wallis H-test was applied to results of 12th week to find out whether the differences in results of test chemicals are significant or not.

## Results

Out of 25 catering establishments and thirty four houses surveyed, 16 (64%) catering establishments and 20 (58.9%) houses had high infestation, 6 (24%) catering establishments and 6 (17.6%) houses had medium, 3 (12%) catering establishments and 8 (23.5%) houses had low cockroach infestation.

A total of 10 catering establishments and 10 houses with high cockroach infestation were considered for random sampling for selection of the trial and control sites. The catering establishments having high infestation were found to be located more proximally to the central garbage dump as well as poor in environmental sanitation. The common cockroach hiding places in the study areas were the food cupboards followed by refrigerators or freezers and under the sinks and water pipes. The infestation in the catering establishments and houses was primarily of German cockroach *Blattella germanica*. The pre-treatment density observation in various catering establishments and houses by the two sampling techniques (visual count method and sticky trap method) is presented in Table 1. It was observed that visual count method

**Table 1. Pre-treatment density of cockroaches by two different sampling methods in (a) catering establishments, and (b) houses**

Treatment area/Control	Pre-treatment density/100 ft <sup>2</sup>	
	Sticky trap method	Visual count method
<i>(a) Catering establishments</i>		
Treatment area 1 (Propoxur)	3	13
Treatment area 2 (Propoxur)	3	10
Treatment area 3 (Synthetic pyrethroid)	4	15
Treatment area 4 (Synthetic pyrethroid)	2	11
Treatment area 5 (Imidacloprid)	3	15
Treatment area 6 (Imidacloprid)	3	21
Treatment area 7 (Fipronil)	2	8
Treatment area 8 (Fipronil)	2	16
Control 1	3	13
Control 2	3	11
<i>(b) Houses</i>		
Treatment area 1 (Propoxur)	3	16
Treatment area 2 (Propoxur)	4	15
Treatment area 3 (Synthetic pyrethroid)	4	19
Treatment area 4 (Synthetic pyrethroid)	5	20
Treatment area 5 (Imidacloprid)	5	22
Treatment area 6 (Imidacloprid)	5	17
Treatment area 7 (Fipronil)	3	12
Treatment area 8 (Fipronil)	3	12
Control 1	3	15
Control 2	5	17

was found superior to sticky trap method of density assessment and therefore, this method was chosen as the post-treatment sampling technique. The percent reduction in cockroach infestation in comparison to controls is presented in Table 2. In propoxur treated catering establishments 90.3% reduction was achieved by 1st week, whereas in houses it was 91% by 1st week. A higher percent reduction of 97.2% in catering establishments and 93.5% in houses was observed by 2nd week and it was 90.3% in catering establishments and 91.4% in houses by the end of 8 weeks post-treatment and by 12th week the percent reductions were declined to 74.1% in catering establishments and 77.5% in houses.

It was observed that 59 and 70.4% reduction was observed in synthetic pyrethroid-treated catering es-

tablishments and houses respectively by 1st week, and later the percent reductions in cockroaches gradually declined over control. After 12 weeks percent reductions were 17 and 50.4% in catering establishments and houses respectively.

In contrast, in case of fipronil and imidacloprid gel treated catering establishments and houses, gradual increase in percent reductions in cockroaches den-

**Table 2. Percent reduction in cockroaches by propoxur, synthetic pyrethroid, imidacloprid and fipronil gels in (a) catering establishments, and (b) houses over control**

Duration in weeks	Percentage reduction (Mean ± SD) in treated sites over control			
	Propoxur aerosol	Synthetic pyrethroid aerosol	Imidacloprid gel	Fipronil gel
<i>(a) Catering establishments</i>				
I	90.3±3.5	59±10.4	61.4±9.7	54.3±18.5
II	97.2±0.5	58.2±3.4	82.2±6	83.8±5.3
III	97±1.2	23.6±22.6	89.1±3.8	88.9±3.3
IV	96.8±1.2	21.8±18.1	86.8±1.7	90.6±2.8
V	95.9±0.3	20.8±18.4	93.7±2.2	92.4±2.8
VI	94.1±1.3	18.8±16.9	95.8±0.8	93.3±3.2
VII	93.3±1.9	18.1±15.9	96.5±0.6	94.2±3.6
VIII	90.3±1.6	18.1±18	95.7±0.4	97.1±2.4
IX	87.7±0.7	19±17.6	94.5±0.6	97±2
X	85.2±0.9	19.5±16.9	93.3±0.9	97.8±1.4
XI	81.9±3.7	19.1±15.9	92.5±1.1	98±1.1
XII	74.1±3.7	17±14.8	90.3±1.2	96.1±2.3
<i>(b) Houses</i>				
I	91±0.3	70.4±2.2	65.6±1	57.9±8.3
II	93.5±1.1	65±2.6	78.5±1.2	74.3±4.9
III	95.2±1.1	63.8±4.9	84.7±2.2	83.1±3.4
IV	96.6±0.7	66.9±3	92.2±0.8	88.1±3.6
V	95.8±0.1	61.7±2.6	95.3±1.8	91.8±4.5
VI	94.1±1.2	52.1±0.5	96.8±0.2	92.1±4.2
VII	93.2±1.6	55.6±1.9	95.9±0.2	93.7±4
VIII	91.4±1.7	53.8±1.8	93.7±1.6	95.1±2.4
IX	89.4±1.3	53.9±3	94.4±1	96.8±1.5
X	86.5±1.5	54.8±2.7	95.5±0.8	97.9±1.4
XI	79.8±2.3	52.9±4	92.2±0.9	98.1±0.4
XII	77.5±2.7	50.4±3.2	90.9±0.7	96.8±0.8

Kruskal-Wallis H-test (results of 12th week) (a) catering establishments— $p < 0.05$ , (b) houses— $p < 0.05$ , which indicates differences in results of four test chemicals were significant

sity over control was observed through 1st week to 12th week (Table 2). Kruskal-Wallis H-test analysis revealed significant differences in percent reductions among all the four treatments in both catering establishments and houses ( $p < 0.05$ ).

### Discussion

Control of cockroaches relies mainly on the use of synthetic chemicals. Most of the chemicals, when used in the form of either aerosol or spray, did not prevent cockroach infestation in and around human habitations due to increase in the incidence of insecticide resistance<sup>15</sup>. The use of baits in cockroach abatement programme is now gaining popularity, due to non-repellent action, preference even in the presence of food materials, easy application techniques and specific and fast action on target species<sup>16</sup>. Hence, baits incorporated with active ingredients, *i.e.* chemicals having moderate mammalian toxicity and safe application techniques are being developed for controlling cockroaches. Performance of such baits in apartments and commercial kitchens infested with cockroaches has been demonstrated. However, the efficacy of baits varies depending on the type of dwelling surfaces and target species<sup>17</sup>.

It was observed in the present study that the cockroach infestation in all the sites ranged from moderate to high and the infestation were primarily of *B. germanica* which has also been found to be the most dominant species in other studies as well in the same area earlier<sup>12</sup>. The prevalence of *B. germanica* is partly due to its relatively small size, high level of fecundity and shorter development time than other cockroach pest species<sup>18</sup>. Besides its biological characteristics, *B. germanica* is also notorious for its ability to develop physiological and behavioural resistance to insecticides<sup>19</sup>. The efficacy of propoxur aerosol in control of German cockroaches has been reported by other workers also in similar settings<sup>12</sup>.

Synthetic pyrethroid aerosol (0.02% deltamethrin + 0.13% allethrin) was found less effective in control of cockroaches in the present study in catering es-

tablishments in comparison to houses as well as it was less effective in comparison to propoxur. Resistance to deltamethrin in *B. germanica* has been reported in some studies<sup>20</sup>. The use of synthetic pyrethroids of the 2nd type (*viz.* deltamethrin) against cockroaches has been recommended by workers because they can produce a higher insecticidal effect as well as irreversible knock-down<sup>21</sup>. However, in the present study the synthetic pyrethroid combination of deltamethrin and allethrin could not bring about the desired reduction in cockroach infestation in comparison to propoxur. Propoxur is also known to cause greater ootheca detachment and reduced hatchability thereafter and therefore has a higher efficacy against cockroaches<sup>22</sup>. Low levels of resistance have been found in *B. germanica* for propoxur whereas high level of resistance for deltamethrin has been found in some other studies<sup>23</sup>.

The results indicate that in imidacloprid and fipronil gel-treated areas progressive reduction in cockroaches density was observed in both settings from first week to 12 weeks. A reduction in cockroach infestation by 94% at the end of 8 weeks post-treatment in our study is comparable to the findings of other studies<sup>13</sup>. Efficacy of imidacloprid in cockroach control in our study was similar to fipronil gel<sup>12</sup>. A reduction in cockroach infestation by 96% at the end of 12 weeks post-treatment in our study with fipronil is comparable to the study carried out by Wang and Bennett<sup>24</sup>.

The study reports the efficacy of propoxur aerosol (2.0%), imidacloprid gel (2.15%) and fipronil gel bait for control of cockroaches in cookhouses. However, in the present study the synthetic pyrethroid combination of deltamethrin and allethrin could not bring about the desired reduction in cockroach infestation. However, propoxur was more effective in reducing the cockroach density by first week in comparison to imidacloprid and fipronil but its efficacy started declining after 8th week onwards. The application of imidacloprid gel and fipronil gel was not only found more convenient to both operators and clients but was also easy to apply in out-of-the-way places (and

was very stable under a wide range of conditions) and there was minimal disruption of the home or workplace.

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