

Integrated pest management (IPM) for the German cockroach (*Blattella germanica* L.) in Jeddah province, Saudi Arabia

ELSIDDIG M. NOURELDIN

General Directorate of Municipal Health, P.O. Box 2727, Doha (Qatar).

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ABSTRACT

Six components {education, vacuuming, sanitation, chemical spray (Lambda-cyhalothrin 2.5% CS), dusting (boric acid), and baiting (imidacloprid 2.15%)} were used in selected houses in Jeddah province to evaluate the efficacy of Integrated Pest Management (IPM) technique against German cockroaches for 12 weeks.

The effect of (IPM) technique on the population counts of the German cockroach was significant at all the post-treatment cockroach counts compared with the initial 24h pretreatment counts and the conventional spray counts. This was reflected in the gradual suppression of the cockroaches mean counts at week two, week four, week eight and week twelve by percentages reduction of 90%, 96.5%, 99%, and 100% respectively.

Key words: Integrated pest management (IPM), *Blattella germanica* L., Jeddah, Saudi.

INTRODUCTION

Cockroaches are the most common urban pests found in human dwellings all over the world. They are considered as the most serious residential pests worldwide. They are found everywhere in the houses, drop feces and spoil food. They also shed their skins as they grow and produce unpleasant smells when their number become large. They are considered by some of the biologists to be one of the most adaptable and successful group of animals (Bennett *et al.* 1997).

Cockroaches are capable of transmitting many pathogens including bacteria, viruses, fungi, protozoa, and pathogenic helminthes that threaten human health. They act as potential transmitters of agents of bacterial diarrhea and nosocomial infection in hospitals (Agbodaze and Owusu 1989, Fotedar *et al.* 1991, Vythilingam *et al.* 1997). In addition, cockroaches not only spoil food but cause allergic reactions and psychological distress (Brenner 1995).

In Jeddah, Saudi Arabia the German cockroach (*Blattella germanica*) was found to be the most dominant species in both dwellings and properties (Nourelidin and Farrag 2008a). Cockroach control in Saudi Arabia relies mainly on the use of liquid insecticides.

Cockroaches are notoriously resilient and difficult to control (Service 2004). Cockroaches have become resistant to commonly used insecticides. The German cockroach, *B. germanica* is resistant to several organochlorines, organophosphates and carbamates and in certain countries resistance to few synthetic pyrethroid insecticides has also been reported (Wooster and Ross 1989, Cochran 1989)

Control strategies should therefore be redirected to emphasize the knowledge of the biology and ecology of the target cockroaches in addition to insecticide use, if any, and should be more selective and less environmentally polluting (WHO 1996).

Because of the problems encountered in controlling pest populations, and in some cases the impossibility of eliminating the pest species completely, the concept of integrated pest management (IPM) has been developed. This concept was originally introduced in agricultural pest situations as integrated pest control (Stern *et al.* 1959) where natural biological control mechanisms were optimized. This was later developed into integrated pest responsible for atopic and allergic reactions in people management, defined then as “the reduction of pest problems by actions selected after the life systems of the pests are understood and the ecological as well as economic consequences of these actions have been predicted, as accurately as possible, to be in the best interests of mankind” (Rabb 1970).

Integrated Pest Management (IPM) is an alternative to conventional, chemical-based pest control (Olkowski *et al.* 1991). It relies on nonchemical approaches plus education and uses comprehensive information on the life cycles of pests and their interaction with the environment to guide pest control. The concept underlying IPM is that pest populations can be controlled by moving their basic survival elements, such as air, moisture, food, and shelter, by blocking their access to apartments by sealing cracks and crevices and by the careful placement of least toxic baits and gels. Maintenance, sanitation, education, and training are the cornerstones of IPM.

Because residents' activities have a great impact on the pest abundance and control result, education of the residents should be an important component of an IPM program. Educational programs had positive impact on residents' attitude (Robinson and Zungoli 1985).

Few systematic studies of IPM have been undertaken in the urban settings. Some have produced positive results, but others report limited success (Campbell *et al.* 1999, Kass and Outwater 2002, Kinney *et al.* 2002, Surgan *et al.* 2002).

Most literature on IPM in man-made structures may be classified into (a) works on the basic biology of pest organisms, including the effects of specific management options (usually

insecticides) on pest populations; these are usually well scrutinized by scientists ; and (b) works on the integration of approaches, details on progress and obstacles in IPM implementations, and cost-benefit assessments of various approaches, which are usually found in the unrefereed trade and technical literature (Schal and Hamilton 1990) .

Since basic studies on cockroaches in Saudi Arabia are still lacking, and to date, no any study on the IPM approach to control cockroaches throughout the country have been published. This study was conducted with the aim of developing an environmental-friendly integrated pest management program for the control of cockroaches as an alternative to conventional method of control.

MATERIAL AND METHODS

General Materials and Methods

Study area and duration

The study was carried out in a residential compound in an urban area at Al-Ajwad district in east of Jeddah city from September 2007 to January 2008.

Houses selected were similar in area (50 m² each). Each house had kitchen, hall, two rooms (bed and dining room), and bathroom.

Cockroach density was estimated in all houses of the compound. Of the 76 similar houses included initially, 48 had high cockroach infestation. Of these 4 houses were selected for IPM treatment by simple random sampling method.

Pre-treatment assessment in field

In every house included in the study, 5 sticky traps were placed around each of the usual harborages of cockroaches (stove, fridge, under the sink, bathroom, and dining room). Traps were removed next morning to estimate the average cockroach density for every house.

Post-treatment density

Post-treatment density was assessed for every house by placing the sticky traps in the same cockroach harborages of pre-treatment. The assessment was done at two, four, eight and twelve weeks after application of control measures. The

percentages reduction of cockroach infestation in the respective houses were calculated using the following formula:

$$\% \text{ Reduction} = \frac{\text{Counts of pre-treatment} - \text{Counts of post-treatment}}{\text{Counts of pre-treatment}} \times 100$$

Statistical analysis

Data was statistically analyzed by using SAS (2001) software program.

Residents cooperation

The individuals whose houses were selected for the conventional and IPM treatments were briefed about the study to get their full cooperation and participation. The precaution to be followed post-treatment in the treated houses were explained to the concerned residents and it was ensured that the same were complied with during the entire trial period.

Conventional control method

The chemical used was Lambda-cyhalothrin 2.5% CS (Demand) in a form of capsulated Suspension (CS). It was applied at the rate of 50ml. per 5 liter of water. The residents were required to empty all cabinets and closets. Once the residents had left the houses, a through insecticides treatment with Lambda-cyhalothrin 2.5% CS was applied with a B&G sprayer system operated at 1.4 kg/cm² (20psi) with fan spray nozzle.

The spray was applied to areas around kitchen cabinets closets, appliances, and toilet facilities and on all baseboards, door and window frames and moldings. In addition, insecticide was directed to cracks and crevices in the kitchen, dining room, and bathroom as well as any additional areas of the house specified by the residents.

IPM Technique

The IPM technique which contained six components {education, vacuuming, sanitation, chemical spray (Lambda-cyhalothrin 2.5% CS), dusting (boric acid), and baiting (imidacloprid 2.15%)} were used in selected houses in Jeddah province. The details of IPM components are as follows:

Public education

After the initial survey, all residents of the

houses in the IPM treatment group and one of the compound management personnel received cockroach IPM education materials. This includes information on cockroach biology, behavior, chemical, and nonchemical control techniques, and IPM principles. During each visit, the residents were asked to cooperate through proper housekeeping, sanitation, and reduction of cockroach harborages.

Additionally, in-home "hands-on" demonstration that focused on how to identify sources of cockroach infestation and how to control the conditions that nurture them, such as leaks, clutter, food sources, and garbage was performed for the residents at the beginning of the experiment.

Vacuuming

A household vacuum (TOSHIBA 2400) was modified by placing a narrow tube on the end of the vacuum hose to extract cockroaches from cracks and crevices. Vacuuming helped in preparation for other control methods. It cleaned out old and new egg capsules, loose fecal materials, and living and dead cockroaches.

Vacuuming was performed by directing the narrow tube into cracks and crevices of the houses selected for IPM technique, as well as, directing it into the frames of doors and windows and any other potential harborages. The vacuumed cockroaches (egg capsules, nymphs or adults) in the bag of the household vacuum was placed in a well sealed bag for disposal.

Sanitation

Residents were taught to thoroughly clean areas beneath cabinets, sinks, stoves, refrigerators, etc. as well as, cupboards, pantry shelves and food storage bins. Clean up spilled foods and liquids. They were asked to avoid leaving scraps of food on unwashed dishes and countertops overnight. In addition, they have been instructed to keep food in tightly sealed containers, rinse cans and bottles before putting in the trash, and transfer garbage outdoors every night into roach-proof receptacles away from the house.

Residents were briefed how to inspect for cockroaches and their egg cases in sacks, cartons, boxes, used appliances and furniture, etc., brought into the home, because infestations are usually

initiated through the introduction of infested materials.

Some structural modifications such as caulking holes in walls where pipes pass through are necessary in the kitchen, bathroom, and other areas of the house were requested from the residents in order to control German cockroaches

Chemical spray (Lambda- cyhalothrin 2.5% CS)

A crack and crevice treatment using Lambda- cyhalothrin 2.5% CS was applied throughout each house in the IPM treatment.

Dusting (boric acid)

Boric acid dust was applied lightly (thin layer), by using a hand duster in: hollow legs of chairs and tables throughout the house, under the sink, in the dead space between the sink and wall,

and around utility pipes, under/behind the refrigerator, stove, into the opening where plumbing pipes enter walls (such as behind the shower and washing machine), into openings around drainpipes and electrical conduits.

Baiting (Imidacloprid 2.15% gel bait)

Imidacloprid 2.15% gel bait (single application at 0.1 gel spots) was used along the back edges and in corners of shelves in cabinets, cupboards, under the kitchen sink, and around the stove and refrigerator.

In addition, gel spots were placed at floor-wall junctions, in corners, next to cracks and crevices. Other treated sites included lower kitchen cupboards, upper kitchen cupboards, the infested sites and potential harborages in the bathrooms and dining rooms.

Table 1: The effect of conventional liquid spray on the population of *Blattella germanica*

% Reduction	Mean* \pm Std Error	Intervals
0.00	30.5 \pm 18.2414 ^a	24 hours before treatment
73	8.25 \pm 6.2899 ^a	2 weeks after treatment
69.7	9.25 \pm 2.4958 ^a	4 weeks after treatment
30.3	21.25 \pm 8.6639 ^a	8 weeks after treatment
(-) 31.1	40 \pm 10.2551 ^a	12 weeks after treatment

*Number of cockroaches per house.

LSD = 31.866

Means with the same letters are not significantly different

Table 2: The effect of Integrated Pest Management (IPM) technique on the population of *Blattella germanica*

Intervals	Mean* \pm Std Error	% Reduction
24 hours before treatment	50 \pm 23.5761 ^a	0.00
2 weeks after treatment	5 \pm 0.7071 ^b	90
4 weeks after treatment	1.75 \pm 0.2500 ^b	96.5
8 weeks after treatment	0.5 \pm 0.2887 ^b	99
12 weeks after treatment	0.00 \pm 0.000 ^b	100

*Number of cockroaches per house.

LSD = 31.800

Means with the same letters are not significantly different

RESULTS

The effect of conventional liquid spray (lambda-cyhalothrin 2.5% CS) on the population of *Blattella germanica*

The population counts of *B. germanica* declined at all the post treatment counts except the last count at week twelve when it witnessed more than 30% increase indicating a recovery of the suppressed population even more than the respective pretreatment levels (Table 1). The rate of declining and increasing was not significantly different ($P>0.05$) from the pretreatment counts (mean = 30.5).

The same was true for the post-treatment population counts of *B. germanica* when compared with each other they showed no significant differences among them ($P> 0.05$).

The efficacy of the chemical was higher at week two post-treatment with a 73% reduction in the population counts, and then declined gradually to 69.7% reduction at week four, 30.3 % at week eight post-treatment till it was no longer effective and the counts of *B. germanica* increased by one third over the 24h pretreatment primary counts in week twelve (Fig 1).The best performance of the chemical was noticed at week two which may be due to the fast knockdown effect of the liquid formulation.

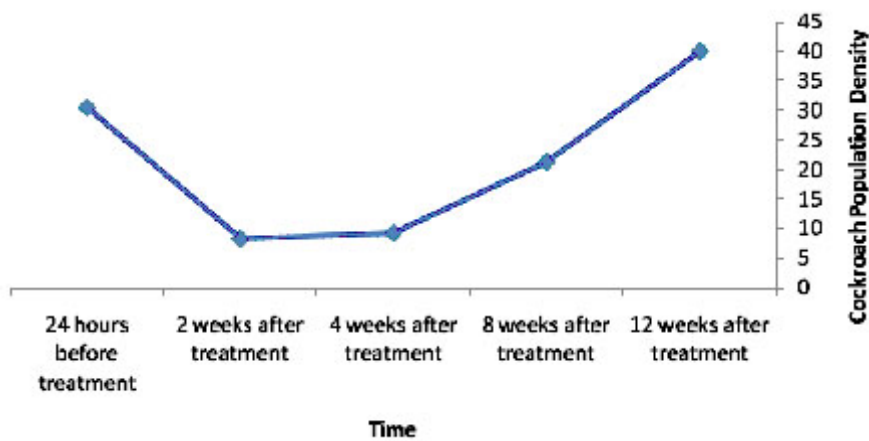


Fig. 1: The Effect of conventional liquid spray on the population of *Blattella germanica*

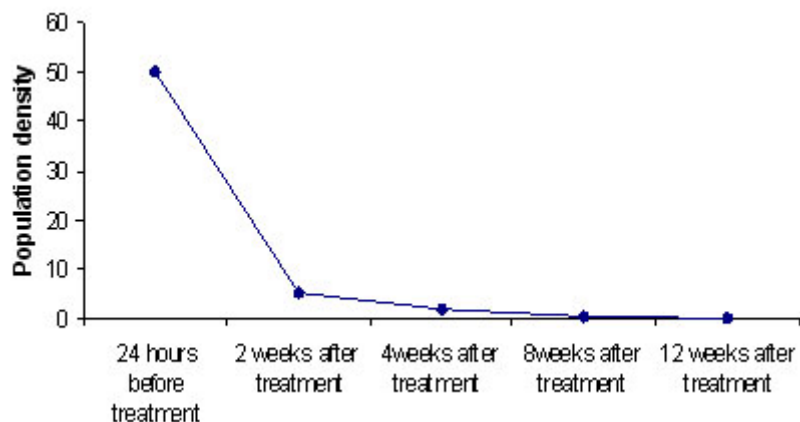


Fig 2: The effect of Integrated Pest Management (IPM) technique on the population of *Blattella germanica*

The effect of Integrated Pest Management (IPM) technique on the population of *Blattella germanica*

Data on (table 2) indicated that the effect of Integrated Pest Management (IPM) technique on the population counts of *B. germanica* was significant at all the post-treatment cockroach counts compared with the initial 24h pretreatment counts ($P > 0.05$) and the application of liquid sprays (table 1).

This was reflected in the gradual suppression of the cockroaches mean counts at week two, week four, week eight and week twelve representing percentages reduction of 90%, 96.5%, 99%, and 100% respectively (table 2 and Fig 2).

Nevertheless, post-treatments counts of *B. germanica* when compared to each other showed no significant difference ($P > 0.05$).

DISCUSSION

Applying conventional liquid spray did not reduce the cockroach population significantly which may be due to the extensive use of lambda-cyhalothrin in Jeddah (Noureldin and Farrag 2008c), or to the repellent effect of the pyrethroid deposits (Ross and Cochran 1992), or to the adhesion of the chemical to the ceramic surface (Branes and Bernnet 1989). The failure of using Lambda-cyhalothrin in controlling cockroaches was also reported by Vythilingam *et al.* (1997).

Results of the efficacy of IPM on the population of German cockroaches are shown on table (2).

The results indicated a percentage reduction of 90% at week two, 96% at week four, 99% at week eight and 100% reduction at week twelve. This result shows a gradual suppression in the cockroach population counts towards the end of the experiment. Additionally, it indicates that some of its components are having a residual effect which may be due to the long lasting effect of both boric acid and imidacloprid gel bait.

Snell and Robinson (1991) reported on a successful cockroach management program

designed for correlation facilities and food-service environments using sticky traps to monitor infestations, and establishing treatment thresholds to achieve significant reductions in infestation levels and insecticide use.

Cockroach populations in the IPM treatment were significantly reduced from an average of 24.7 cockroaches per unit before treatment to an average 3.9 cockroaches per unit in the fourth month, and the suppressed cockroach populations remained constant for the remaining 8 months of the test (Miller and Meek 2004)

Other workers such as Brenner *et al.* (2003), reported that the frequency of cockroach infestation in the IPM intervention households declined by more than 50% over the 6 months of the study. They also found that individually tailored IPM can be successful and cost-effective in an urban community. They reported that IPM techniques are effective and relatively economical in controlling cockroach infestation in urban apartment dwellings at the household level, if community residents are directly involved in the development and implementation of the project at every stage and are provided with systematic education and "hands-on" guidance by pest control experts skilled in IPM techniques. These efforts must be supported by an infrastructure of knowledgeable building managers, superintendents, and other staff who provide services to urban apartments.

IPM programs in urban settings differ from those in other environments in that they make greater use of public education (Milligan 1984).

Jeong *et al.* (2006) reported that health education and follow-up visits were found to significantly reduce the densities of indoor arthropods. The best way of treating allergic disease is believed to be a combination of environmental control and medication. They recommended that continuous and repeated health education, at a frequency of more than once a year, is required for effective control of indoor allergens. Allergy levels were reduced in homes where residents received training (Klitzman *et al.* 2005)

In this study, it was observed that the awareness of the residents with cockroaches and their control through IPM technique was excellent and improved with time, and with outstanding results of cockroach reduction from week to another. Their willing and interest to continue monitoring and controlling the cockroaches were also observed.

McConnell *et al.* (2003) mentioned that reduction in number of cockroaches and in total allergen in bedding dust could be achieved by educational intervention by peer educators.

Because residents' activities have a great impact on the pest abundance and control result, education of the residents should be an important component of an IPM program. Educational programs had positive impact on residents' attitude (Robinson and Zungoli 1985).

Robinson and Zungoli (1995) reported that a successful German cockroach management program includes consideration of components such as: target audience, target pest, monitoring techniques, and control strategies specific to the target sites, educational materials and evaluation. An understanding of the basics of these components enables professional pest control operators to design and implement successful cockroach management programs in specific environment.

The most important aspect of cockroach pest management is monitoring the pest population and responding to treatment thresholds that are determined following communication with the client or customer. This will place the use of chemical and nonchemical control strategies on a need basis. This approach will often limit (but not skip) the use of insecticides in the home or workplace environment, and retains insecticide effectiveness. The benefits of a pest management approach are safe and effective control of cockroaches with limited use of insecticide.

In this study, it was found that vacuuming not only removes cockroaches but also has the potential to reduce cockroach allergens because vacuuming can remove large amount of cockroach products (e.g., dead cockroaches, cockroach feces,

cast skins, egg cases), Wang and Bennett (2006b).

Noureldin and Farrag (2008b) demonstrated that sanitation can improve the performance of liquid insecticides in controlling German cockroaches. They also obtained better results by using combinations of Boric acid dust and gel bait with liquid insecticides (Noureldin and Farrag 2008c)

Only a few previous studies have rigorously evaluated the effectiveness of IPM interventions to determine whether they can reduce indoor cockroach levels in urban households. These investigations have reported mixed results (Campbell *et al.* 1999) and have noted that introduction of IPM in inner-city communities may encounter multiple challenges (Kinney *et al.* 2002). Some researchers have argued that IPM will be effective in multiple-unit apartment buildings only if it takes place in the context of a building wide program of repair and pest control (Kass and Outwater 2002, Kinney *et al.* 2002). Brenner *et al.* (2003) observed that individual tenants can successfully control cockroach infestation in their own apartments without using chemical pesticide sprays. The critical element in successful implementation of IPM by low-income, urban households appears to be the simultaneous application of multiple nonchemical approaches to pest control, including education, repair, least-toxic extermination, reinforcement, and repetition, all in the context of a community partnership and in a culturally sensitive environment.

It is interesting to note that residents, whether or not in an IPM-treatment dwellings, almost always rated cockroach infestation as more serious than other common house pests.

It is also interesting to note that IPM technique has stimulated residents to conduct monitoring and control of the cockroaches by their own.

In this study, it seems that the cost of IPM technique is higher than the single or combined control measures particularly at the initiation of the program, yet its effects will continue for a longer periods than do the other control measures.

Nonetheless, it was noticed that this cost was reduced with time after program establishing and became almost the same as that of other control measures towards the end of the study.

CONCLUSION

In this study, 100% suppression in the cockroach populations was obtained at week twelve post-treatment. This result indicates clearly that IPM program used against German cockroach in Jeddah province is a successful one and should always be used to control cockroach infestations in the dwellings, as well as, in all property types in Jeddah province and other provinces in Saudi Arabia.

This study and other studies demonstrated that IPM program may offer benefits under certain circumstances but will not lead to a pesticide free control. It could lead to the best means of achieving optimization or minimization of chemical control.

The results obtained in this study indicated that research in the following areas is needed

The cost benefit analysis of the conventional and the IPM program considering the undesirable pesticides effects.

Long term assessment of the IPM strategy.

Evaluation of the relative effectiveness of the different components of the IPM program.

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