

Original Article

Evaluation of Five Local Formulated Insecticides against German Cockroach (*Blattella germanica* L.) in Southern Iran

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Abstract

Background: The German cockroach, *Blattella germanica* L., is a serious household and public health pest worldwide. Control of this species has been very difficult to achieve. Toxicity of cypermethrin EC10%, deltamethrin EC5%, diazinon EC0.5%, lambda-cyhalothrin EC5% and Nagon® (permethrin+propoxur oil liquid1%) commercial formulations were investigated against adult males of German cockroaches collected from four hospitals of Bandar Abbas City, southern Iran, during 2006. These insecticides have been used for cockroach control in this city.

Methods: The tests were carried out only on males by the glass jar contact method recommended by the WHO.

Results: Maximum mortality rates of 20, 35, 90, and 100% were obtained after one hour contact to label-recommended doses of cypermethrin, deltamethrin, lambda-cyhalothrin, diazinon and permethrin+propoxur insecticides, respectively. KT_{50} results were different from 5.68 min for permethrin+propoxur mixture to 240.37 min for cypermethrin. German cockroach showed < 80 per cent mortality using three pyrethroid insecticides.

Conclusion: It seems that the label-recommended concentrations of these insecticides were wrong and lower than WHO advised for cockroach control. For monitoring of resistance it is recommended to do more tests using the pure active ingredient of these insecticides.

Keywords: German cockroach, Commercial insecticides, Resistance, Hospital, Iran

Introduction

According to World Health Organization report, cockroaches have been in existence for about 360 million years (Cochran 1982). These insects are important pests because they spread filth and ruin food, fabrics and book-bindings. They disgorge portions of their partially digested food at intervals and drop feces. They also discharge a nauseous secretion both from their mouths and from glands openings on the body which gives a long-lasting, offensive cockroach smell to areas or food visited by them. Cockroaches are not usually the most important cause of a disease, but they may play a supplementary role

in some allergic diseases as well as spread of some diseases like: diarrheal diseases, amebic dysentery, cholera, leprosy, plague, typhoid fever and viral diseases such as poliomyelitis. Therefore they might be important in transmission of nosocomial infections (Pai et al. 2004).

The German cockroach, *Blattella germanica* (L.), is a serious household and public health pest worldwide. Control of this species has been very difficult to achieve. In order to keep it under control, different organochlorine and organophosphate insecticides have been used, as well as carbamate and pyrethroid compounds. Still this species has been developing resistance to these compounds. At pre-

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sent, resistance has become a substantial problem that sometimes causes failure of control operations in many countries (Atkinson et al. 1991). Heavy infestations of cockroaches can be effectively managed by chemical control measures, followed by environmental management to deprive them of food and shelter. The German cockroach is resistant to different insecticides (Cochran 1995, Hanafi-Bojd and Sadaghiani 2001, Vatandoost and Mousavi 2001).

The present study was conducted to determine the susceptibility levels of this species to insecticides currently being used in its control program in four hospitals of Bandar Abbas City, southern Iran.

Materials and Methods

Study area

The investigation was carried out over a period of 10 months of 2006 at Bandar Abbas City, Hormozgan Province (25° 24' - 28° 57' N. and 52° 41' - 59° 15' E.), bordered by the Persian Gulf. This city is the main economic seaport of Iran.

Cockroach strains

This research was carried out in four training hospitals of Hormozgan University of Medical Sciences in Bandar Abbas City, called: Shahid Mohammadi, Shariati, Koodakan and Ebne-Sina. *B. germanica* specimens were collected from different parts of the hospitals. The collections were made by trapping and hand catch methods. Traps were made by glass bottles containing bread and butter. The upper internal edge of the bottles, were coated with a fine layer of butter to prevent the escape of cockroaches. These traps were externally covered with dark paper. The samples were collected weekly and sent to the Bandar Abbas Training and Public Health Research Center. Cockroach colonies were reared in an insectary, maintained in big glass containers at 27±2° C and a relative humidity of 77±3%.

They were fed with rabbit food, bread, soybean and water.

Chemicals

To determine the levels of resistance, five commercial formulations of insecticides were used: cypermethrin EC10% (PARTO-NAR, Co.), deltamethrin EC5% (PARTO-NAR Co.), diazinon EC0.5% (GIAH Co.), lambda-cyhalothrin EC5% (PARTO-NAR, Co.) and Negon® (Permethrin+Propoxur) oil liquid 1% (IRAN CHEMICAL PRODUCTION Co.). These insecticides formulated in Iran and are using for insect pests (such as cockroaches).

Contact glass jar test

Tests were conducted on adult males by WHO standard method (WHO 1970). The duration of contact was 1 h and then cockroaches were transferred to holding cups. Results of mortality were recorded after 24 h. Concentrations were prepared based on label-recommended doses of each commercial insecticide. The label recommended concentrations for pyrethriod insecticides were as follows:

Deltamethrin 2.5% EC, 50 ml in 5 lit water; lambda-cyhalothrin 5% EC, 50-70 ml in 8 lit water; cypermethrin 10% EC, 50-70 ml in 5 lit water. Diazinon was EC 60% (that we prepared its 0.5% solution) and the Negon® oil liquid 1% was labeled "ready to use".

Therefore, we diluted the insecticides based on their label and then pipetted 1 ml of each solution into labeled glass jars (surface area= 180 cm²). The upper inside lip of the jars were smeared with a thin layer of butter to prevent the cockroach escape. The insecticides were deposited evenly in the inner jar surface by rolling the jar on a flat surface until all liquid solvent had evaporated. Ten adult males were introduced into the jar and knockdown of the cockroaches was recorded at 5 min intervals. Four replicates and one control were carried out for each strain using every insecticide.

Data analysis

Results from all replicates for each insecticide were pooled and subjected to probit analysis (Finney 1971).

Results

Results of mortality after 1 h contact to label-recommended dosages of cypermethrin, deltamethrin, lambda-cyhalothrin, diazinon and Negon® (permethrin+propoxur) are showed in Table 1. Although in the case of three pyrethroid insecticides the mortality rates of cockroaches were lower than 91%, but two other

insecticides (Diazinon and Negon®) caused 100% mortality. The highest mortality rates for deltamethrin, lambda-cyhalothrin and cypermethrin was 35, 90 and 20%, respectively.

KT₅₀ values of tested cockroaches in contact to the insecticides were varied from a minimum of 5.68 min for Negon® in the Ebne-Sina strain to a maximum of 240.37 min for cypermethrin in Koodakan strain, respectively (Table 2). KT₅₀ levels of three pyrethroid insecticides: cypermethrin, lambda-cyhalothrin and deltamethrin were distinctly lower in Shahid Mohammadi strain.

Table 1. Mortality results of one hour contact of male German cockroaches (*Blattella germanica* L.) to five commercial insecticides, Bandar Abbas, southern Iran, 2006

Insecticide Hospital	Cypermethrin		Lambda-cyhalothrin		Deltamethrin		Diazinon		Propoxur+Permethrin	
	No.	%	No.	%	No.	%	No.	%	No.	%
Shahid Mohammadi	2	5	36	90	14	35	40	100	40	100
Shariati	5	12.5	33	82.5	6	15	40	100	40	100
Ebne-Sina	8	20	22	55	7	17.5	40	100	40	100
Koodakan	3	7.5	16	40	9	22.5	40	100	40	100
Control	0	0	1	2.5	0	0	0	0	0	0

Table 2. KT₅₀ (min) values of *Blattella germanica* from four hospitals of Bandar Abbas City, southern Iran, in contact to five commercial formulation of insecticides, 2006

Insecticide Hospital		Cypermethrin	Lambda-cyhalothrin	Deltamethrin	Diazinon	Propoxur+Permethrin
Shahid Mohammadi	Lower	47.72	18.41	31.66	44.05	7.75
	KT ₅₀	53.78	20.99	35.49	46.79	9.89
	Upper	63.70	23.57	40.22	50.23	11.89
Shariati	Lower	81.64	32.61	59.68	33.89	5.36
	KT ₅₀	118.67	35.29	71.49	35.27	7.22
	Upper	441.97	38.17	109.87	36.65	8.76
Ebne-Sina	Lower	-	31.23	67.67	38.22	3.61
	KT ₅₀	-	35.69	85.77	40.26	5.68
	Upper	-	41.45	135.29	42.17	7.44
Koodakan	Lower	113.66	43.39	53.86	32.68	11.95
	KT ₅₀	240.37	55.52	69.26	34.94	14.02
	Upper	9292.93	90.62	103.61	37.27	15.91

Table 3. WHO label recommended concentrations against cockroaches for the studied insecticides

Insecticide	Recommended concentration (%)	
	WHO	Label
Cypermethrin	0.05-0.2	0.0014
Deltamethrin	0.03-0.05	0.025
Lambda-cyhalothrin	0.015-0.03	0.004
Diazinon	0.5	0.5
Permethrin	0.25	1
Propoxur	1	1

Discussion

Cockroaches are difficult to control with insecticides for several reasons, e.g. they may become resistant to commonly used compounds. Moreover, many insecticides are repellent to them and are therefore avoided (Wooster and Ross 1989). Chemical control gives only temporary relief and, wherever possible, it should be accompanied by environmental sanitation and house improvement (Schal 1988).

In this study, German cockroaches showed less than 80% mortality using cypermethrin, deltamethrin and lambda-cyhalothrin (except for two strains) (Table 1). An investigation on efficacy of synthetic pyrethroids (0.02% deltamethrin+0.13% allethrin) and propoxur aerosol in the control of German cockroach in India showed that 89.36-87.8 and 77.95-59.74% reductions were achieved with propoxur and synthetic pyrethroid treatment respectively by first week post-treatment (Agrawal et al. 2005). Results of another study on German cockroaches using commercial insecticides in north of Iran showed 100% mortality after 1h contact with propoxur 0.32%, permethrin 0.32%, bendiocarb 0.24% and pirimiphos methyl 0.16% (Haghi et al. 1997).

The resistance levels of 12 strains of German cockroach in Peninsular Malaysia were low to high (2.8 to 92x) for carbamates (pro-

poxur and bendiocarb), low (2.0 to 7.6x) for organophosphate (chlorpyrifos) and low to moderate (1.0 to 23x) for pyrethroids (cypermethrin and permethrin) when compared to a susceptible strain (Lee et al. 1996). Such levels were observed in our study and we found diazinon and permethrin+propoxur based insecticides very effective, rather than the other tested insecticides. WHO introduced the insecticides and their concentrations for control of cockroaches (Chavasse and Yap 1997, Rozendaal 1997). Table 3 shows the WHO recommended concentrations of insecticides that are used in this study in comparing with the label recommended dose of them for cockroaches control. It can be observed that some commercial insecticides advised very lower concentrations of active ingredient than WHO recommendation that may be the cause of low mortality in our tests. So for resistance monitoring of German cockroaches in the studied hospitals of Bandar Abbas, it is recommended to test the active ingredient of tested insecticides based on WHO concentrations.

Study of susceptibility level of German cockroach to lambda-cyhalothrin in Tehran, the capital city of Iran, showed 4 out of 5 strains of this species are tolerant and only one is susceptible (Ladonni 1997). The irregular use of insecticides, especially pyrethroids, in the insect pests control programs, is resulted to increase their tolerance or resistance levels. For a successful control program against German cockroach in these hospitals, it is recommended to use correct concentrations of effective insecticides from different groups. Application method and accuracy in spraying with due attention to cockroach shelters, are another factors for success. In the study of permethrin resistance ratio (RR) by tarsal contact tests on first-instar nymphs of *B. germanica*, KT_{50} of 8.41 min and LT_{50} of 12.82 with permethrin 15 mg/m² were obtained and all wild strains showed significant levels of resistance to permethrin, with RR

of 17-27 fold at the KT_{50} level (Ladonni 2000). Our minimum of KT_{50} that observed in mixed insecticide that contains propoxur+ permethrin 1% was ranged from 5.68 to 14.02 min (Table 2). The susceptibility level of eleven strains of German cockroach was evaluated against permethrin and fipronil by topical application. In all strains, cockroaches showed different degrees of resistance to permethrin (Nassirian et al. 2006). We observed 100% mortality using Negeron® that contains permethrin, but it is a mixture of pyrethroid and carbamate insecticides. This mixture destroys all resistance mechanisms and if there was a compound of only permethrin, we could make a better inference about the resistance status of *B. germanica* strains of Bandar Abbas. First nymphal stages of different strains of *B. germanica* were tested to diazinon 2% using insecticide impregnated papers in Tehran City, Iran (Ladonni et al. 1997). Comparison of LT_{50} of field strain with the susceptible insectary strain showed 3 of them had tolerance ($1.5 < RR < 2.5$). Our study showed 100% susceptibility to the WHO recommended dose of diazinon. Insecticide resistance studies on *B. germanica* from Cuba showed evidence of resistance to cypermethrin, deltamethrin and lambda-cyhalothrin (Diaz Pantoja et al. 2000).

The resistance to six insecticides was investigated on field strains of German cockroaches caught in hospitals from various parts of Poland. The tested field strains showed high or moderate resistance to permethrin, deltamethrin, cypermethrin and bendiocarb, moderate resistance or tolerance to etofenproks, and tolerance or susceptibility to propoxur (Gliniewicz et al. 1996). Although we found different rates of mortality for these pyrethroids ranging from 7.5 to 90% (Table 1), it may be partly due to incorrect concentrations advised by their manufacturing company.

To determine the resistances in cohorts of *B. germanica* from hospitals and households of Thailand to organophosphates, carbamates

and pyrethroids, bioassays by topical application were carried out. Resistance ratio (RR) was determined by comparing the LD_{50} of the collected cohorts with that of a susceptible cohort. RR ranges of chlorpyrifos, propoxur and cypermethrin in the hospitals were 2.04-28.80, 2.86-30.86 and 1.95-14.05 and those in the household were 1.92-17.72, 6.93-62.50 and 2.80-27.35, respectively. Significant correlations among the RRs of the three insecticides were separately found in the hospitals and households, indicating the existence of cross resistance among the three groups of insecticides (Pai et al. 2005).

The history of cockroach control spraying in our studied hospitals showed that carbamate and pyrethroids were mainly used such as: propoxur, cyfluthrin, deltamethrin and lambda-cyhalothrin. Inappropriate use of these insecticides can end to tolerance/resistance in cockroaches. Therefore, we suggest the label recommended concentration of cypermethrin, deltamethrin and lambda-cyhalothrin commercially insecticides that we used in this study have to change based on the WHO suggested concentrations to obtain best results in cockroach control program of Bandar Abbas hospitals.

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