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Table 1. The probit regression parameters of knock-down test with different pyrethroids against a susceptible and 4 wild strains of *Blattella germanica*.

Insecticide tested	Strains	a	b±S.E.	X^2(d.f.)	KT_{50}±S.E.	KT9±S.E.	RR*
Beta-cyfluthrin	Insectary	-1.20	10.18±1.42	4.10 (7)	13.16±0.31	17.53±1.02	-
	H-1 (wild)	-1.28	4.12±0.56	11.96 (10)	19.48±1.13	41.93±2.09	1.48
	H-2 (wild)	-1.40	5.11±0.66	6.24 (9)	18.81±0.87	33.49±4.20	1.43
	H-3 (wild)	-2.08	8.36±1.05	1.64 (10)	17.73±0.47	25.23±1.70	1.35
	H-4 (wild)	-1.48	6.05±0.74	8.12 (9)	17.54±0.68	28.57±2.72	1.33
	H-5 (wild)	-1.71	6.13±0.72	6.26 (11)	18.99±0.66	30.72±2.48	1.44
Sumithrin	Insectary	0.69	4.89±0.66	13.83 (8)	7.22±0.37	13.21±1.77	-
	H-1 (wild)	-2.14	4.91±0.57	12.53 (14)	27.31±1.06	49.81±4.91	3.78
	H-2 (wild)	-1.97	5.63±0.64	15.84 (14)	22.38±0.76	37.80±3.26	3.09
	H-3 (wild)	-1.44	4.11±0.39	7.29 (15)	22.35±1.04	45.82±4.34	3.09
	H-4 (wild)	-3.91	5.23±0.55	14.23 (17)	55.93±1.82	98.30±8.19	7.75
	H-5 (wild)	-3.99	5.83±0.60	15.79 (17)	48.45±1.43	80.37±5.79	6.71
Permethrin	Insectary	0.063	5.06±0.61	3.27 (9)	7.51±0.36	13.46±1.33	-
	H-1 (wild)	-1.18	5.21±0.59	11.44 (13)	16.84±0.64	29.66±2.49	2.24
	H-2 (wild)	-2.33	6.57±0.69	6.30 (12)	22.61±0.70	35.42±2.30	3
	H-3 (wild)	-1.74	5.12±0.52	8.96 (15)	21.86±0.79	38.89±3.23	2.9
	H-4 (wild)	-2.09	5.92±0.64	9.33 (14)	22.59±0.74	37.21±3.07	3
	H-5 (wild)	-1.23	4.60±0.45	8.37 (15)	18.53±0.76	35.23±3.02	2.5
Lambdacyhalothrin	Insectary	-2.18	8.33±1.08	16.53 (11)	18.29±0.45	26.07±1.75	-
	H-1 (wild)	-4.17	6.99±0.81	13.05 (14)	39.43±1.04	60.12±4.15	2.16
	H-2 (wild)	-1.21	4.02±0.44	11.16 (15)	19.99±0.91	41.64±4.39	1.09
	H-3 (wild)	-4.69	7.02±0.77	25.20 (17)	45.80±1.14	71±4.28	2.50
	H-4 (wild)	-5.63	8.57±1.01	10.58 (12)	45.40±1.10	64.07±4.06	2.48
	H-5 (wild)	-5.48	8.52±0.84	6.56 (15)	43.94±0.94	62.14±2.99	2.40

7.22±0.37, 7.51±0.36, 18.29±0.45 minutes to beta-cyfluthrin, sumithrin, permethrin and lambdacyhalothrin respectively. The susceptibility levels of wild strains were compared with the susceptible strain. They showed some increases in KT50s 1.33 to 1.48, 3.09 to 7.75, 2.24 to 3 and 1.09 to 2.50 folds to the latter insecticides respectively. Comparison of the knock down tests on the wild strains indicated that all the strains were susceptible to beta-cyfluthrin (RR < 1.5 fold), but four out of 5 strains were tolerant (RR = 2.16 to 2.5 folds) , and one was susceptible (RR< 1.5) to lambdacyhalothrin. Permethrin tests on the 5 strains revealed that three out of 5 strains were resistant to permethrin (the RR ranged between 2.9 to 3 folds) and the other two were tolerant (RR ranged between 2.24 to 2.5 folds) (table 1).

Further tests on the sumithrin indicated that , all the strains were resistant to sumithrin (the RR ranged between 3.09 to 7.75 folds).

The relationship between DDT and pyrethroid resistance was studied in a DDT-resistance (kdr) strain of *B.germanica* (7). Cross-resistance broadly developed to all pyrethroids when tested by topical application, but in a surface contact method test, the cross-resistance spectrum did not extend to cypermethrin and deltamethrin. Cypermethrin resistance in German cockroach was assessed by surface and topical application methods (11). In topical application the resistance ratio (RR) was 122.6 folds, while this ratio for surface contact was 2.9 folds.

Review of pyrethroid application for house pest control in Iran showed that, permethrin has a long history of residual application for more than 20 years. Sumithrin is available only in the form of aerosol formulation as a non residual insecticide. Beta - cyfluthrin has recently been introduced in Iran for house hold pest control , but it has not yet been used so far , but lambdacyhalothrin is available in market and it is widely used for German cockroach. It could be concluded that the development of permethrin and lambdacyhalothrin resistance/ tolerance to a number of strains of German cockroach is as the result of direct use of these later insecticides in human dwelling. The observed resistance to sumithion is unlikely related to use of such small amount of this compound in cockroach control programmes; but it is likely related to uses of other pyrethroids and hence developing cross-resistance to sumithrin.

Insecticides: The technical grade of the following insecticides were used in this study:

- Beta-cyfluthrin (98.7% a.i) , supplied by Bayer.
- Lambdacyhalothrin (98% a.i) , supplied by Zeneca.
- Sumithrin (94% a.i) , supplied by Sumitomo.
- Permethrin (93.6% a.i) , supplied by Zeneca).

Bio assay: Bio assay test was carried out according to the method recommended by WHO (2,9). A glass jar were treated by 3 ml of a known volume of insecticide dissolved in acetone and horizontally rotated evenly until the acetone evaporated. Concentration of insecticides that caused a range of effects were established in preliminary experiments. Susceptibility tests were conducted on newly emerged adults of first generation of wild strains collected from infested area. Adult females of German cockroach in lots of 10 to 15 in 3-4 replicate were placed in treated jar and their knock down were recorded periodically until all the insects knock down at some preestablished end point.

The glass jars were treated with beta - cyfluthrin , lambdacyhalothrin, permethrin and sumithrin at the rate of 2 , 3 , 20 , and 20 mg a.i/m^2 respectively. The pooled data from replicate tests were analyzed by probit analysis method of Finney (1971) using SPSS statistical package on an IBM computer , The results are presented in table 1. For evaluation of resistance , the resistance ratio (RR) , i.e. the ratio of KT_{50} of wild strain to susceptible strain , were calculated for each strain. The value of RR was used for estimation of susceptibility level of each strain as follows:

RR < 1.5	susceptible
RR 1.5 to 2.5	tolerant
RR > 2.5	resistant

Results and Discussion

The result of knock down tests on the adult females of six different strains of German cockroach , the BLA-SUS (the susceptible strain) and the 5 wild strains, to beta-cyfluthrin, lambdacyhalothrin, permethrin, cypermethrin and sumithrin are presented in tables 1. The BLA - SUS strain showed the KT50s of 13.16±0.31,

Introduction

The German cockroach , *Blattella germanica* (L) , is a serious pest of flats, homes, and food-handling facilities. German cockroach control relies on the application of a variety of formulated insecticides. The active formulation should have low mammalian toxicity , high cockroach toxicity and preferably nonrepellent. Development of widespread resistance , rapid breakdown of insecticides in urban environments , poor sanitation and optimal cockroach breeding conditions are factors contributing to the difficulties in controlling this pest. Unfortunately , *B.germanica* has developed resistance to many of the insecticides commonly used against it (1,5,6,8,10). Cochran (1989) performed bioassay on 45 field-collected strains of German cockroaches with several pyrethroid , two carbamate (propoxur and bendiocarb), and four organophosphate (diazinon , chlorpyrifos , acephate and malathion) insecticides, a number of strains showed resistance to all insecticide tested , and half of the strains were resistant to pyrethrins. The susceptibility of German cockroach collected from 5 different hospitals in Tehran were tested with a number of insecticides (4). Out of them , some strains showed resistance to permethrin, gogilhat, cypermethrin and diazinon.

Pyrethroids have been receiving consideration attention in German cockroach control programmes. The purpose of this study was to determine the susceptibility level of different strains of *B.germanica* to some traditional pyrethroids like permethrin and sumithrin ; and also to some newer pyrethroids like lambdacyhalothrin and beta - cyfluthrin.

Materials and methods

Strains: The following strains of German cockroaches were used in this investigation.

- A susceptible strain which has been maintained in our insectary without insecticide exposure for at least 17 years.
- Five wild strains, collected from different infested flats belong to four separated building in Tehran. The strains were maintained and colonized in continuous culture under a photoperiod of 12:12 (L:D) at 26±2 C and RH of 50±5. The insects were supplied with a water vial , and dry dog chow and dry bread.

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SUSCEPTIBILITY OF DIFFERENT FIELD STRAINS OF *BLATTELLA GERMANICA* TO FOUR PYRETHROIDS *(ORTHOPTERA: BLATTELLIDAE)*

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Key words: *Blattella germanica, resistance, pyrethroids, Iran*

Abstract

The susceptibility of 5 wild strains of German cockroach collected from five infected flats in Tehran were assessed by tests of surface contact method to cyfluthrin , permethrin , sumithrin and lambdacyhalothrin. Comparison of the result of knockdown tests on the wild strains with a standard susceptible strain indicated that all the strains are resistant to sumithrin , i.e. , resistance ratio , the RR, ranged between 3.09 to 7.75 folds ; but susceptible to beta - cyfluthrin (RR < 1.5). Permethrin tests on the field collected strains revealed that 3 out of 5 strains are resistant (RR = 2.9 to 3 folds) but two are tolerant to permethrin (RR ranged between 2.24 to 2.5 folds). Further tests on the lambdacyhalothrin showed that 4 out of 5 strains are tolerant and one is susceptible. It could be concluded that development of permethrin and lambdacyhalothrin resistance/tolerance in a number of strains of German cockroach is as the result of direct use of these later insecticides in human dwelling. Sumithrin resistance is unlikely related to use of such small amount of this compound in cockroach control programmes ; but it is likely related to uses of other pyrethroids and hence developing cross-resistance to sumithrin.

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