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## Susceptibility status of German cockroaches, *Blattella germanica* (L.) to carbamate and pyrethroid insecticides within surface contact method in Shiraz city, Iran

**Seyed Mohsen Mohebbi Nodez, Azam Rafatpanah, Mousa Khosravani, Fatemeh Shahidi Hakak and Azim Paksa**

**Abstract**

German cockroaches (*Blattella germanica*) is one of the most important pests that have extensively pervaded into human dwellings and hospitals. Two class of insecticides named carbamate and pyrethroids were examined on two strains of cockroaches (dormitory (D) and hospital (H)) through the surface contact method. The obtained lethal doses of Carbaryl (WP 85%) were much higher than the standard dose for both strains. In the case of cyfluthrin WP 10%, the fatal doses were extracted 2.765 and 3.265 mg/m<sup>2</sup> for D and H strains whereas the suggested dose was 3.768 mg/m<sup>2</sup>. The toxicity dosages of Lambdacyhalothrin (WP 10%) were 1.413 and 3.265 mg/m<sup>2</sup> for D and H strains respectively. Both strains have exhibited the tolerance to them. H and D strains were tolerant to pyrethroids. Notably, pyrethroids should be rotationally used with others insecticides relaying to integrated pest management (IPM).

**Keywords:** German cockroach, surface contact, pyrethroid, carbamate, Iran

**1. Introduction**

*Blattella germanica* (German Cockroach) as a detrimental pest that damages food materials in human dwellings<sup>[1]</sup>. Further, they can adapt to the environment with poor nutritional resources thereby, they suppose as opportunist pest<sup>[2]</sup>. Cockroaches order comprise over 400 species that widespread throughout the world. Moreover, 18 genera of this insects are accounted as domesticated pests (synanthrope)<sup>[3]</sup>. They serve as a mechanical vector of a variety of pathogens and cause asthma or allergic interaction in human<sup>[4, 5]</sup>. The cockroach has a history going back to the 360 million years ago nearly<sup>[6]</sup>. In addition to, bacterial agents (e.g. *Klebsiella* spp. and *Pseudomonas*) have been isolated from hospital cockroaches and patients, therefore, they have potentially the medical importance<sup>[7]</sup>. Also, they harbored numerous species of intestinal parasites and viruses. Some predominant biological agents have been identified as protozoan microorganisms (*Entamoeba histolytica*), helminths (*Trichuris trichiura*), viruses (densovirus) and several fungal parasites (*Aspergillus* spp.)<sup>[8, 9, 10]</sup>. Although the role of cockroaches in the transmission of agents to human is not clear, they can be considered as the carrier of microorganisms associated with nosocomial and bacterial infections<sup>[3]</sup>. For this reason, combat cockroach is critical for man and application of chemical insecticides have expanded against these annoying pests. On the other hand, resistance to pesticides is a negative phenomenon due to using a wide range of chemical insecticide. Some of the strains have shown resistance to up to 8-12 insecticide<sup>[11, 12]</sup>. For instance, diazinon altered with propoxur in control interventions at the end of the 1960s<sup>[13]</sup>. German cockroach has demonstrated resistance to some insecticides such as diazinon (organophosphate), permethrin (pyrethroids) and bendiocarb (carbamate) in Iran<sup>[14]</sup>. One strain of cockroaches was shown tolerance to propoxur in a study conducted by Ladonni *et al*<sup>[15]</sup>. Continuously, many of researchers carried out the surveys on the resistance process in order to reduce the emergence of resistance<sup>[11]</sup>. Our project aims the evaluation of susceptibility level of two class of insecticides (i.e. carbamates and pyrethroids) in the student' dormitories and hospitals of Shiraz University of medical sciences. This results can be used for control of cockroach especially in crowded places that many people live together in

restricted space such as garrison, prison, and dormitory. Also, the finding has profit under public health programme and assist us to improve our knowledge within environmental and public health particularly in the tropics and subtropic regions.

## 2. Material and Methods

### 2.1 Cockroach collection

German cockroaches were gathered from student' dormitories and hospitals of Shiraz University of Medical Sciences. The hand catch method was used to collect the cockroaches from kitchens and bathrooms. Then they transfer into the cylindrical plastic container which a little amount of grease was applied to the inside of it to prevent escape. Two strains were separately placed into the wide mouth jars containing a piece of bread, starch, soya, sugar, and water for feeding. Jars were maintained in insectarium at  $27\pm 2^{\circ}\text{C}$  temperature,  $60\pm 10\%$  humidity and 12:12 photoperiod (L:D). Overall, 2760 male cockroaches were used in the bioassay test.

### 2.2 Insecticides

The tested insecticides were selected according to World Health Organization guideline (16). The technical grade of pesticides is provided into 2 groups: carbamate and pyrethroids bendiocarb 80%, carbaryl 85% and propoxur 25% belong to carbamates and formulated as a wettable powder (WP). Pyrethroids are included cyfluthrin WP 10% and lambda-cyhalothrin WP 10%.

### 2.3 Bioassay test

The experiments were performed within the framework of WHO and Scharf technics [16, 17]. The initial dose per an insecticide was calculated based on its manufactures guideline then the required acetone as a solvent provided per each jar (with a surface area of  $188.4\text{ cm}^2$ ). Continuously, these volumes (insecticide-acetone solution) infused into glass jars and roll until all of the acetone to be vaporized so that insecticide dose was deposited evenly over the inner surface

of the jars. Moreover, all of them were anesthetized with chloroform then ten cockroaches were introduced into per jar and exposure to inner of it. The exposure time was 30 min and the mortality rates were recorded after 24 h. Each dose of insecticide was tested into 4 replications. 10 cockroaches considered as a control group per concentration that they solely were exposure to solvent. The topical application per dosage continued until the mortality rate reached 100%. In the case of mortality  $< 100\%$ , the next volume of treated dose doubled. The similar treatment used for lower doses from standard dose. A concentration was reported as a diagnostic/lethal dose which had 100% mortality. Jars were well being washed and dried for next using. The database was analyzed by probit regression [18].

## 3. Results

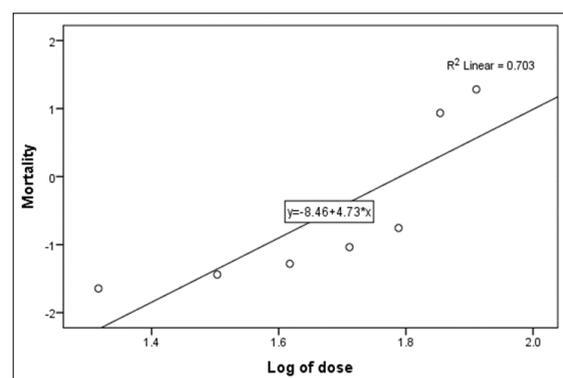
Carbamate insecticides were tested at 5 concentrations. The lethal dose of propoxur (WP 25%) were 18 and 25.12  $\text{mg/m}^2$  for dormitory (D) and hospital (H) strains respectively while the standard dose was  $6.28\text{ mg/m}^2$ . From 11 concentrations of bendiocarb (WP 80%), 3.392  $\text{mg/m}^2$  and 7.522 dosages had 100% mortality for D and H strains. It should be noted that the standard dose was  $2.261\text{ mg/m}^2$ . The fatal doses of carbaryl (WP 85%) were measured 51.448% and 100.44  $\text{mg/m}^2$  up to 14 concentrations for D and H strains in regard to the standard dose was  $10.362\text{ mg/m}^2$ . In the case of pyrethroids, the lethal doses of Lambda-cyhalothrin (WP 10%) were determined 2.73 and 3.265  $\text{mg/m}^2$  for D and H strains respectively. Indeed, the suggested dose was  $3.768\text{ mg/m}^2$  for this insecticide. The toxicity dosages were obtained 2.965 and 3.365  $\text{mg/m}^2$  for dormitory and hospital strains in the case of cyfluthrin (WP 10%) whereas the recommended dose was  $3.768\text{ mg/m}^2$ .  $\text{LD}_{50}$  values have been indicated in Table 1. The  $\text{LD}_{50}$  profile was more different for carbaryl. The mortality rates have increased in parallel with the higher dosage. Mortality reaches to a benchmark of 100% more rapidly and points have a sharper slope.

**Table 1:** Probit analysis of mortality rate of German Cockroaches treated with surface contact using pyrethroid and carbamate insecticides (D, dormitory; H, hospital)

Insecticide	Strain	No.	Slope $\pm$ SE	R <sup>2</sup> Linear	Chi-square (Sig.)	LD <sub>50</sub> (mg/kg)
Bendiocarb	D	40	$1.82\pm 0.290$	0.964	0.130	3.681
	H	40	$3.67\pm 0.574$	0.952	0.105	3.900
Carbaryl	D	40	$4.25\pm 0.565$	0.995	0.259	24.287
	H	40	$4.73\pm 0.627$	0.703	0.000	62.376
Propoxur	D	40	$2.06\pm 0.565$	0.881	0.100	4.008
	H	40	$3.23\pm 0.397$	0.918	0.009	10.263
Cyfluthrin	D	40	$3.89\pm 0.579$	0.834	0.002	2.083
	H	40	$2.6\pm 0.439$	0.997	0.005	2.061
Lambdacyhalothrin	D	40	$2.22\pm 0.304$	0.959	0.318	1.733
	H	40	$4.08\pm 0.493$	0.954	0.127	1.914

## 4. Discussion

Our knowledge presented that bendiocarb has the most effect followed by propoxur and carbaryl. Lambda-cyhalothrin from pyrethroids had more toxicity efficacy on German cockroach in comparison with cyfluthrin partially. In general, cockroaches exhibited high tolerance levels in the carbamate group (bendiocarb, carbaryl, and propoxur) especially carbaryl. The previous studies support these finding [19, 20]. Moreover, they were tolerant to pyrethroids group. The resistance to carbaryl was 4.97 times greater than the standard concentration. These findings implied that the dormitory strain is tolerant to this insecticide. On the other word, this value was 9.97 fold higher than the standard dose for hospital strain. Therefore, H strain is resistant to carbaryl (Figure 1).



**Fig 1:** Probit transformed responses of Carbaryl on hospital strain of German Cockroaches

Perhaps, frequent spraying may result in high resistance rate concerning to D strain. Bendiocarb (48 g/l) affected the D and H strains with 80% and <20% mortalities. Resistance to bendiocarb was >1.5 times more than standard dose in D strain but this value was >3.33 times more than criteria dose in H strain. As a consequence, D strain is tolerant also H specimens are resistant to bendiocarb. However, collected specimens were more susceptible to bendiocarb than others using pesticides from carbamate group. Current findings are accordance with numerous surveys [19, 20, 21]. In recent literature, cockroaches were less resistant to propoxur in similar to previous works [11, 22, 23]. Some investigations have proved that tested insects were more susceptible to propoxur [24]. Both of strains revealed tolerance to using pyrethroids (cyfluthrin and Lambda-cyhalothrin). In contrast, some views have been shown the toxicity effect of these pesticides on the German cockroaches [25, 26, 27]. Although some tolerance/resistance have been documented in Iran, this group is also enrolled as the adulticide for control of mosquitoes [28, 29]. The similar dynamic of resistance presented in multiple of compounds. For example, chlorpyrifos (organophosphate) has been examined on susceptible and field strains of cockroaches subsequently, a range of resistance was reported [4, 30]. German cockroaches were resistant to malathion (organophosphate) within surface contact method [31].

## 5. Conclusion

It is suggested that more study is needed to clarify the resistance or susceptibility of cockroaches in other parts of Iran. Significantly, improving the quality of the environment and using poisoned baits can be considered. In current years, pyrethroids are excessively used against cockroaches in Iran subsequently, insects presented tolerance even resistance to these insecticides. They should be rotatory applied. Moreover, they can be used into integrated pest management (IPM) strategy to prevent cross-resistance.

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