academicJournals

Vol. 6(7), pp. 90-97, August, 2014
DOI: 10.5897/JEN2014.0098
Article Number: C87F2BF47193
ISSN 2006-9855
Copyright © 2014
Author(s) retain the copyright of this article
http://www.academicjournals.org/JEN

Journal of Entomology and Nematology

*Full Length Research Paper*

# Toxicological and residual effect of Deltamethrin and Chlorpyrifos against the German cockroach, *Blattella germanica* (Linnaeus) (Insecta: Blattodea: Blattellidae)

**Kemabonta, K. A.*, Ohadiwe, A. and Adetoro, F. A.**

Department of Zoology, Faculty of Science, University of Lagos, Akoka, Lagos, Lagos State, Nigeria.

Received 15 June 2014; Accepted 25 June 2014

**The toxicological and residual properties of two insecticidal agents, Deltamethrin and Chlorpyrifos were evaluated against the German cockroach, *Blatella germanica* in laboratory bioassay. The insecticides were diluted in both aqueous and oil-based solvents and tested against the roaches in pre-determined concentrations and untreated control. Experimental cages were either completely sealed after exposure or perforated to simulate fumigation and disinfestation regimes, respectively. Mortality data generated from acute toxicity studies revealed that oil-based Deltamethrin (5%v/v) was more effective (100%) than aqueous solution (53.3%) within similar durations in both chambers. Chlorpyrifos (5%v/v) revealed an acute mortality of 100% for both oil-based and aqueous solutions in both chambers. Residual effect of both Deltamethrin and Chlorpyrifos was dose/time-dependent, with oil-based solution more effective than the aqueous solution. Computed lethal time revealed that $LT_{50}$ showed significant difference ($P<0.05$) between aqueous solution of both insecticidal agents for fumigation treatment. A similar trend was observed for the oil-based solutions of both insecticides in the disinfestations treatment. The implication of this finding in terms of choice of insecticides for acute toxicity and residual efficacy, impact of diluting agents, and sustainable approach to roach control in Nigeria was discussed.**

**Key words:** *Blatella germanica,* disinfestation, fumigation chambers.

## INTRODUCTION

The German cockroach (*Blatella germanica*, Linnaeus) is one of the most common species worldwide and prominent household cockroaches in the world, and can be found throughout many human settlements (Jacobs, 2007). It is particularly associated with restaurants, food processing facilities, hotels and nursing homes. It is however less prominent in temperate environments, probably due to its volume/surface area ratio which is a major hindrance to cold tolerance (Rust et al., 1995).

*B*. *germanica* is the most commonly encountered of the household pest**s** species in Nigeria. It is also the most persistent and difficult to control (Fasulo, 2002). This is due to its larger egg ratio per capsule than other species that infest households and structures. Secondly, it has the shortest developmental period from hatching to sexual maturity; thus, populations of German cock-

*Corresponding author E-mail: kkemabonta@unilag.edu.ng.

Author(s) agree that this article remain permanently open access under the terms of the Creative Commons Attribution License 4.0 International License

roaches usually build up faster than other species. Thirdly, German cockroach nymphs have relatively enhanced chance of survival than other species because the female carries the egg capsule during the entire embryonic development of the nymph. These result in the nymphs avoiding many potential environmental hazards as compared to detached and/or isolated eggs. Thus, more nymphs are likely to hatch, with resultant higher reproductive potential. Fourthly, German cockroach nymphs are smaller than most other cockroaches; thus, they are able to conceal themselves in many places which are inaccessible to those of other species. In fact, in a commercial kitchen, there may be potentially thousands of cracks and crevices young cockroaches can hide in and remain protected (Fasulo, 2002). *B. germanica* has aggregation pheromones associated with their droppings, which have the effect of increasing the level of aggregation or clumping of individuals in the population (Engelmann, 1970; Roth, 1970). These biological factors, combined with their highly adaptive feeding habits and other behaviors, give the German cockroach advantages toward increased chances for survival and consistently maintaining high populations.

The control of *B*. *germanica* using conventional insecticidal agents remains a challenge in many parts of the world, due to increased spate of resistance development. *B. germanica* resistance to insecticides was first detected in chlordane use in Corpus Christi, Texas, USA in 1952 (Heal et al., 1953). Thereafter, an increasing number of cases have been documented in the USA (Rust and Reierson, 1991, Zhai and Robinson, 1991), Canada (Batth, 1977), Europe (Chapman *et al*., 1993), and Japan (Umeda et al., 1988). Currently, resistance to all the major groups of insecticides (organochlorines, organophosphates, carbamates and pyrethroids) by *B. germanica* has been reported (Cochran, 1995). Increased tolerance and potential resistance to other novel insecticides, such as sulfluramid (Schal, 1992) and abamectin (Cochran, 1994), along with behavioral changes in response to glucose attractant (glucose-aversion) in cockroach bait (Silverman and Ross, 1994) have been reported recently.

Few studies have been carried out on the control of *B*. *germanica* using different types and/or formulations of insecticides in Nigeria. This study therefore seeks to investigate the comparative insecticidal efficacies of Deltamethrin and Chlorpyrifos against *B. germanica* in laboratory bioassay, identify the impact of different diluents on the effectiveness of the two insecticides. Moreover, it seeks to evaluate the residual activities of the two insecticides, both as fumigation and disinfestation agents, against *B. germanica*

## MATERIALS AND METHODS

### Site of the experiment

Culture of the German cockroach, *B. germanica* was maintained in the laboratory at the Zoological Gardens, Department of Zoology, University of Lagos, where all bioassays were also carried out.

### Insecticides used

Insecticides used, Deltamethrin (2.5 and 5% v/v) and Chlorpyrifos (2.5 and 5% v/v) were purchased from registered agrochemical retail stores around Lagos Island axis of Lagos in Lagos State Nigeria. The choice of diluents was water and diesel, respectively.

### Insect culture

Adults and nymphs of the German cockroach were collected from students' cupboards in Fagunwa Hall, a female residential Hostel within the University Campus, as well from the insectary of the Department of Zoology, University of Lagos to set up a mass culture of *B. germanica.* The insects were kept in plastic vials which were smeared with petroleum jelly to prevent the cockroach from moving out of the vials. The vials were also covered with a muslin cloth and striped with rubber band to keep the insects in place.

While the culture lasted, the roaches were fed thrice a week with crumbs of bread and/or biscuits, with water also placed in the container. The containers were regularly cleaned and insect frass and faeces removed. The petroleum jelly at the edge of the vial was also renewed to prevent escape of the roaches upon opening the vial. Cleaning was done using wet foam rubbed sparingly round the containers and the dirt's packed out with a piece of serviette paper.

### Experimental procedure

The experiment was carried out using the two aforementioned insecticides, two different concentrations and each treatment was replicated three times. Moreover, two different containers were used- perforated at the top (disinfestation procedure $I_o$) while the other was fumigation process ($I_c$)- where the fumigation containers were not perforated. Experimental cages were either completely sealed after exposure or perforated to simulate fumigation and disinfestation regimes, respectively. The procedure was in accordance with that of Shahi et al. (2008) with slight modifications.

### Toxicity test

All life stages of *B. germanica* (except the first, second nymphal stages, and gravid females) were used for the toxicity tests. Deltamethrin and Chlorpyrifos insecticide formulation were used in accordance with the instruction on the labels. Four concentrations 2.5 and 5% (v/v) of water; 2.5 and 5% (v/v) of diesel were used. Each formulation was impregnated on filter paper and air-dried. Excess liquid was drained off, and thereafter, ten (10) randomly picked *B. germanica* were confined into each jar.

The upper surface of the jar was lightly greased with petroleum jelly to prevent escape of the insects (redundancy). There were two controls-jars with only water or only diesel sprayed on the filter paper. Each treatment was replicated three times. Mortality of *B. germanica* was observed after 5, 10, 15, 20, 30 min to the $4^{th}$ h post treatment and the number of dead *B. germanica* was counted and recorded. The jars containing treated and untreated filter papers were kept aside on laboratory bench and used for the residual experiments.

At one week after treatment, German roaches were re-introduced into the various vials containing the treated filer papers including the control to check the residual effect of these insecticides on the roaches. The same procedure was used as in the first experiments (for four hours), after which the experiment was stopped and cock-

**Table 1.** Mean mortality values for both water (positive control) and diesel (negative control) against *B. germanica*.

| Time | Water | Diesel | |
|---|---|---|---|
| | | $I_O$ | $I_C$ |
| 5 min | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 |
| 10 min | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 |
| 15 min | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 |
| 20 min | 0.00±0.00 | 0.00±0.00 | 10.00±0.00 |
| 30 min | 0.00±0.00 | 6.70±5.80 | 10.00±0.00 |
| 45 min | 0.00±0.00 | 13.30±5.80 | 20.00±0.00 |
| 1 h | 0.00±0.00 | 13.30±5.80 | 20.00±0.00 |
| 2 h | 0.00±0.00 | 26.70±5.80 | 26.70±5.80 |
| 3 h | 0.00±0.00 | 26.70±5.80 | 43.30±5.80 |
| 34 h | 0.00±0.00 | 36.70±11.60 | 43.30±5.80 |

$I_O$ = Disinfestation; $I_C$ = fumigation.

roaches discarded. Same experiment was repeated after two weeks.

#### Quantal response

Mortality readings were taken for cockroaches when no part of the body or limb movement was observed upon pricking with a *camel hair brush* and waiting for ten minutes for any movement to occur. Responses of cockroaches to the various experimental set up were noted and written down and the parameters used in taking records included the knock down time and rate of mortality per minutes/hours. Four hours was used, because that is the maximum time used for insect bioassay or toxicity test as long as it is in contact with the insect.

#### Statistical analysis

Statistical analysis of the results was also done after the results have been ascertained and its corresponding mean and standard deviation were recorded against time. This was done using the equations:

Mean, $\bar{x} = \Sigma FX / \Sigma F$

Standard deviation= $\sqrt{\Sigma(x - \bar{x})n/} \quad -1$

The lethal time value ($LT_{50}$) and the regression slope for each treatment were obtained using probit analysis (SPSS 2000). Mean percentage of insect mortality value was subjected to arcsine transformation. Means were compared using LSD test (SPSS 2000).

## RESULTS

### Mortality rate in *B. germanica* exposed to diluents and insecticides

### Mortality in *B. germanica* exposed to diesel and water

Insects exposed to diesel started dying at 20 and 30 min after treatment in disinfestation (Io) and fumigation (Ic) chambers, respectively. The highest mortality of 43.3% was recorded in fumigation chambers at 4 h after treatment ($I_C$). No mortality was recorded on insects exposed to water treatment (Table 1).

### Acute and residual effect of aqueous and diesel diluted Deltamethrin and Chlorpyrifos exposed to *B. germanica*

In aqueous Deltamethrin, mortality of *B. germanica* was recorded after 30 and 45 min for the and 5% (v/v) treatments, respectively. The highest mortality recorded (53.3%) was in 2.5% (v/v) ($I_O$-Dis-infestation) (Table 2). On the other hand, 100% mortality was recorded after 45 min in all the replicates and treatments with diesel diluted Deltamethrin.

At one week after treatment, mortality was recorded after 30 min (Table 3) with 5% ($I_C$-fumigation) and 2.5% (v/v) ($I_C$-disinfestation) having the highest (30%) and least mortalities (13.3%), respectively. On Diesel diluted Deltamethrin, mortality was recorded at 15 minutes and highest mortality (40%) was recorded at 4 h after introducing the insects in the fumigation and disinfestation chambers.

No mortality was recorded for *B. germanica* on water diluted Deltamethrin at 2 weeks after treatment until after 4 h with 5% (v/v) ($I_C$-fumigation) having the highest mortality (10%). On the other hand, diesel diluted Deltamethrin had less than 20% mortality at 2 h after introducing the insects. 5% (v/v) ($I_C$-fumigation) had the highest mortality of 16.7%, respectively (Table 4).

### Acute and residual effect of aqueous and diesel-diluted *Chlorpyrifos* on *B. germanica*

Mortality of *B. germanica* exposed to Chlorpyrifos was dose-dependent. *Chlorpyrifos* (5% (v/v) mixed with diesel applied to *B. germanica* in the fumigation and disinfestation chambers gave 100% mortality at 30 min after treatment while 100% mortality was recorded at 2 h (Ic ) and 3 h (Io) at same concentration with aqueous *Chlorpyrifos* (Table 5).

No death was recorded in all replicates at one week after treatment until 30 min of exposure, while 5% (v/v) ($I_C$-fumigation) had the highest mortality (33.3%) after 4 h (Table 6).

On the other hand, there was no mortality count for *B. germanica* introduced two weeks post-treatment, until after 4 and 3 h exposure to aqueous and oil-based Chlorpyrifos, respectively. Higher concentration of 5% v/v, recorded 23% mortality, after 4 h exposure in the fumigation chambers (Table 7).

A summary of the immediate and residual effect of Deltamethrin and Chlorpyrifos after 4 h exposure is shown in Table 8. In all, percentage mortality was directly dose-dependent and inversely time-dependent. 100%

**Table 2.** Mean mortality of both aqueous and diesel-diluted Deltamethrin against *B. germanica* (initial).

| Time | Control | Water | | | | Diesel | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | 2.5% (v/v) | | 5% (v/v) | | 2.5% (v/v) | | 5% (v/v) | |
| | $I_O$ & $I_C$ | $I_0$ | $I_C$ | $I_O$ | $I_C$ | $I_O$ | $I_C$ | $I_O$ | $I_C$ |
| 5 min | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 |
| 10 min | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 | 56.70±23.10 | 86.70±5.80 | 73.30±15.30 | 83.30±5.80 |
| 15 min | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 | 80.00±10.00 | 100.00±0.0 | 83.30±5.80 | 90.00±10.00 |
| 20 min | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 | 96.70±5.80 | 100.00±0.0 | 93.30±5.80 | 93.30±5.80 |
| 30 min | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 | 6.70±11.60 | 23.30±20.80 | 100.00±0.00 | 100.00±0.0 | 100.00±0.00 | 100.00±0.00 |
| 45 min | 0.00±0.00 | 6.70±5.80 | 0.00±0.00 | 6.70±11.60 | 26.70±15.30 | 100.00±0.00 | 100.00±0.0 | 100.00±0.00 | 0.00±0.00 |
| 1 h | 0.00±0.00 | 6.70±5.80 | 10.00±0.00 | 6.70±11.60 | 30.00±17.30 | 100.00±0.00 | 100.00±0.00 | 100.00±0.00 | 0.00±0.00 |
| 2 h | 0.00±0.00 | 30.00±17.30 | 16.70±5.80 | 13.30±11.60 | 33.30±11.60 | 100.00±0.00 | 100.00±0.00 | 100.00±0.00 | 0.00±0.00 |
| 3 h | 0.00±0.00 | 43.30±28.90 | 16.70±5.80 | 26.70±23.10 | 43.30±5.80 | 100.00±0.00 | 100.00±0.00 | 100.00±0.00 | 0.00±0.00 |
| 34 h | 0.00±0.00 | 53.30±11.60 | 23.30±15.30 | 43.30±5.80 | 40.00±0.00 | 100.00±0.00 | 100.00±0.00 | 100.00±0.00 | 0.00±0.00 |

$I_O$ = Disinfestation; $I_C$ = fumigation.

**Table 3.** Residual effect (mortality) of both aqueous and diesel-diluted Deltamethrin against *B. germanica* (one week).

| Time | Control | Water | | | | Diesel | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | 2.5% (v/v) | | 5% (v/v) | | 2.5% (v/v) | | 5% (v/v) | |
| | $I_O$ & $I_C$ | $I_O$ | $I_C$ | $I_O$ | $I_C$ | $I_O$ | $I_C$ | $I_O$ | $I_C$ |
| 5 min | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 |
| 10 min | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 |
| 15 min | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 | 16.70±5.80 | 30.00±0.0 | 23.30±5.80 | 30.00±0.00 |
| 20 min | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 | 16.70±5.80 | 30.00±0.0 | 23.30±5.80 | 30.00±0.00 |
| 30 min | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 | 0.0±0.00 | 16.70±5.80 | 30.00±0.0 | 23.30±5.80 | 36.70±5.80 |
| 45 min | 0.00±0.00 | 6.70±5.80 | 3.30±5.80 | 6.70±11.60 | 0.00±0.00 | 26.70±5.80 | 33.30±5.80 | 23.30±5.80 | 36.70±5.80 |
| 1 h | 0.00±0.00 | 6.70±5.80 | 3.30±5.80 | 20.00±0.00 | 30.00±0.00 | 30.00±1.000 | 33.30±5.80 | 26.70±11.60 | 36.70±5.80 |
| 2 h | 0.00±0.00 | 6.70±5.80 | 3.30±5.80 | 20.00±0.00 | 30.00±0.00 | 30.00±10.00 | 33.30±5.80 | 26.70±11.60 | 36.70±5.80 |
| 3 h | 0.00±0.00 | 16.70±5.80 | 3.30±5.80 | 20.00±0.00 | 30.00±0.00 | 30.00±0.00 | 33.30±5.80 | 26.70±11.60 | 36.70±5.80 |
| 4 h | 0.00±0.00 | 16.70±5.80 | 13.30±5.80 | 20.00±0.00 | 30.00±0.00 | 30.00±0.00 | 33.30±5.80 | 26.70±11.60 | 40.00±0.00 |

$I_O$= Disinfestation; $I_C$ = fumigation.

mortality was recorded in *B. germanica* when newly introduced to both aqueous and oil-based *Chlorpyrifos* as well as *Deltamethrin* in both fumigation and disinfestation chambers. Diesel exposed to *B. germanica* gave 43 and 36% mortality in fumigation and disinfestation chambers, respectively. Residual effect of Deltamethrin and Chlorpyrifos recorded a maximum of 40% after 4 h in one week after treatment in the

**Table 4.** Residual effect (mortality) of both aqueous and diesel-diluted Deltamethrin against *B. germanica* (two weeks).

| Time | Control | Water | | | | Diesel | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | 2.5% (v/v) | | 5% (v/v)2. | | 2. 5% (v/v) | | 5% (v/v) | |
| | $I_O$ & $I_C$ | $I_O$ | $I_C$ | $I_O$ | $I_C$ | $I_O$ | $I_C$ | $I_O$ | $I_C$ |
| 5 min | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 |
| 10 min | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 |
| 15 min | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 |
| 20 min | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 |
| 30 min | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 |
| 45 min | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 |
| 1 h | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 |
| 2 h | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 |
| 3 h | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 | 6.70±5.80 | 10.00±0.00 | 13.30±5.80 | 16.70±5.80 |
| 4 h | 0.00±0.00 | 3.30±5.80 | 3.30±5.80 | 3.30±5.80 | 10.00±0.00 | 6.70±5.80 | 10.00±0.00 | 13.30±5.80 | 16.70±5.80 |

$I_O$ = Disinfestation; $I_C$ = fumigation.

**Table 5.** Mean mortality of both aqueous and diesel-diluted Chlorpyrifos against *B. germanica* (initial).

| Time | Control | Water | | | | Diesel | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | 2.5% (v/v) | | 5% (v/v) | | 2. 5% (v/v) | | 15/300ML | |
| | $I_O$ & $I_C$ | $I_O$ | $I_C$ | $I_O$ | $I_C$ | $I_O$ | $I_C$ | $I_O$ | $I_C$ |
| 5 min | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 | 33.30±32.20 | 46.70±15.30 | 16.70±20.80 | 43.30±15.30 |
| 10 min | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 | 26.70±37.90 | 53.30±15.30 | 63.30±25.20 | 43.30±23.10 | 66.70±23.10 |
| 15 min | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 | 10.00±17.30 | 60.00±10.00 | 56.70±20.80 | 73.30±15.30 | 53.30±47.30 | 86.70±5.80 |
| 20 min | 0.00±0.00 | 50.00±17.30 | 40.00±30.00 | 10.00±17.30 | 70.00±10.00 | 63.30±15.30 | 80.00±17.30 | 56.70±49.30 | 86.70±5.80 |
| 30 min | 0.00±0.00 | 76.70±5.80 | 86.70±11.60 | 43.30±32.20 | 76.70±5.80 | 73.30±5.80 | 96.70±5.80 | 100.00±0.00 | 100.00±0.00 |
| 45 min | 0.00±0.00 | 83.30±15.30 | 93.30±5.30 | 66.70±28.90 | 93.30±5.30 | 86.70±11.60 | 100.00±0.00 | 0.00±0.00 | 0.00±0.00 |
| 1 h | 0.00±0.00 | 93.30±5.30 | 96.70±5.80 | 76.70±5.80 | 96.70±5.80 | 100.00±0.00 | 100.00±0.00 | 0.00±0.00 | 0.00±0.00 |
| 2 h | 0.00±0.00 | 100.00±0.00 | 100.00±0.00 | 93.30±5.30 | 100.00±0.00 | 100.00±0.00 | 100.00±0.00 | 0.00±0.00 | 0.00±0.00 |
| 3 h | 0.00±0.00 | 100.00±0.00 | 100.00±0.00 | 100.00±0.00 | 100.00±0.00 | 100.00±0.00 | 100.00±0.00 | 0.00±0.00 | 0.00±0.00 |
| 4 h | 0.00±0.00 | 100.00±0.00 | 100.00±0.00 | 100.00±0.00 | 100.00±0.00 | 100.00±0.00 | 100.00±0.00 | 0.00±0.00 | 0.00±0.00 |

$I_O$= Disinfestation; $I_C$ = fumigation.

fumigation chambers.

In the fumigation chambers, $LT_{50}$ of aqueous Deltamethrin and Chlorpyrifos (5% (v/v)) were 195 and 15 min respectively, while Deltamethrin and Chlorpyrifos mixed with diesel were 9 and 6 min respectively. While under disinfestation chambers,

**Table 6.** Mean residual effect (mortality) of both aqueous and diesel-diluted Chlorpyrifos against *B. germanica* (one week).

| Time | Control | Water | | | | Diesel | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | 2.5% (v/v) | | 5% (v/v) | | 2.5% (v/v) | | 5% (v/v) | |
| | | $I_O$ | $I_C$ | $I_O$ | $I_C$ | $I_O$ | $I_C$ | $I_O$ | $I_C$ |
| 5 min | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 |
| 10 min | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 |
| 15 min | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 | 16.70±5.80 | 13.30±5.80 | 20.00±0.00 | 16.70±5.80 |
| 20 min | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 | 16.70±5.80 | 13.30±5.80 | 20±.000.00 | 16.70±5.80 |
| 30 min | 0.00±0.00 | 10.00±10.00 | 16.70±5.80 | 13.30±5.80 | 20.00±0.00 | 16.70±5.80 | 16.70±5.80 | 20.00±0.00 | 20.00±0.00 |
| 45 min | 0.00±0.00 | 10.00±10.00 | 16.70±5.80 | 13.30±5.80 | 20.00±0.00 | 20.00±0.00 | 20.00±10.00 | 26.70±5.80 | 23.30±5.80 |
| 1 h | 0.00±0.00 | 20.00±10.00 | 26.70±5.80 | 30.00±0.0 | 33.30±11.60 | 23.30±5.80 | 26.70±5.80 | 30.00±0.00 | 33.30±5.80 |
| 2 h | 0.00±0.00 | 20.00±10.00 | 26.70±5.80 | 30.00±0.0 | 33.30±11.60 | 26.70±5.80 | 30.00±0.00 | 33.30±5.80 | 40.00±10.00 |
| 3 h | 0.00±0.00 | 20.00±10.00 | 26.70±5.80 | 30.00±0.0 | 33.30±11.60 | 26.70±5.80 | 30.00±0.00 | 33.30±5.80 | 40.00±10.00 |
| 4 h | 0.00±0.00 | 20.00±10.00 | 26.70±5.80 | 30.00±0.0 | 33.30±11.60 | 26.70±5.80 | 30.00±0.00 | 33.30±5.80 | 40.00±10.00 |

$I_O$= Disinfestation; $I_C$ = fumigation.

**Table 7.** Mean residual effect (mortality) of both aqueous and diesel-diluted Chlorpyrifos against *B. germanica* (two weeks).

| Time | Control | Water | | | | Diesel | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | 2.5% (v/v) | | 5% (v/v) | | 2.5% (v/v) | | 5% (v/v) | |
| | | $I_O$ | $I_C$ | $I_O$ | $I_C$ | $I_O$ | $I_C$ | $I_O$ | $I_C$ |
| 5 min | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 |
| 10 min | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 |
| 15 min | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 |
| 20 min | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 |
| 30 min | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 |
| 45 min | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 |
| 1 h | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 |
| 2 h | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 |
| 3 h | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 | 10.00±0.00 | 13.30±5.80 | 20.00±0.00 | 23.30±5.80 |
| 4 h | 0.00±0.00 | 3.30±5.80 | 3.30±5.80 | 10.00±0.00 | 10.00±0.00 | 10.00±0.00 | 13.30±5.80 | 20.00±0.00 | 23.30±5.80 |

$I_O$ = Disinfestation; $I_C$ = fumigation.

**Table 8.** Percentage mortality after four hours of exposure.

| Parameter | | 2.5% (v/v) | | 5% (v/v) | |
|---|---|---|---|---|---|
| | | $I_O$ (%) | $I_C$ (%) | $I_O$ (%) | $I_C$ (%) |
| Diesel | Control | 36 | 43 | | |
| Water | Control | 0 | 0 | | |
| Deltamethrin/water | Initial | 53 | 23 | 43 | 50 |
| | One week | 16 | 13 | 20 | 30 |
| | Two weeks | 3 | 3 | 3 | 10 |
| Deltamethrin/diesel | Initial | 100 | 100 | 100 | 100 |
| | One week | 30 | 33 | 26 | 40 |
| | Two weeks | 6 | 10 | 13 | 16 |
| Chlorpyrifos/water | Initial | 100 | 100 | 100 | 100 |
| | One week | 20 | 26 | 30 | 33 |
| | Two weeks | 3 | 3 | 10 | 10 |
| Chlorpyrifos/diesel | Initial | 100 | 100 | 100 | 100 |
| | One week | 26 | 30 | 33 | 40 |
| | Two weeks | 10 | 13 | 20 | 23 |

**Table 9.** Lethal time values for Deltamethrin (initial).

| Lethal time | Aqueous | | | | Diesel | | | |
|---|---|---|---|---|---|---|---|---|
| | 2.5% (v/v) | | 5% (v/v) | | 2.5% (v/v) | | 5% (v/v) | |
| | $I_O$ | $I_C$ | $I_O$ | $I_C$ | $I_O$ | $I_C$ | $I_O$ | $I_C$ |
| $LT_5$ (minutes) | 49 | 67 | 45 | 16 | 6 | 7 | 5 | 5 |
| $LT_{50}$ (minutes) | 209 | 528 | 358 | 195 | 10 | 9 | 9 | 9 |
| $LT_{95}$ (minutes) | 880 | 4000 | 3000 | 2000 | 19 | 11 | 18 | 16 |

the $LT_{50}$ was 358, 9, 37 and 12 min, respectively (Tables 9 and 10).

## DISCUSSION

The study evaluated the effectiveness of two insecticides *Chlorpyrifos* (an organophosphate) and Deltamethrin (a Pyrethroid) on the control of the German cockroach, *B. germanica*. Only aqueous and oil-based Chlorpyrifos and Deltamethrin (oil based) gave 100% mortality of *B. germanica* within the four hours of exposure period. However, the efficacy of both diluents decreased with increase in residual time.

The experiment shows that Chlorpyrifos was more effective than Deltameth*rin* at the concentration used. The $LT_{50}$ of (5% (v/v)) aqueous Chlorpyrifos for both dis-infestation (13 min) and fumigation (5 min) trials against *B. germanica* were found to be lower when compared with those exposed to aqueous Deltamethrin (358 and 195 min, respectively), of same concentrations and conditions. Moreover, mortality responses (5% (v/v)) of aqueous Chlorpyrifos for both disinfestations and fumigation trials against *B. germanica* were found to be higher than those of insects exposed to aqueous Deltamethrin. A similar trend was observed in the diesel-diluted insecticidal exposure at both concentrations for fumigation and disinfestation against *B. germanica.*

Diesel-diluted insecticidal treatments recorded significantly higher mortality responses than those of aqueous treatments for all concentrations against *B. germanica.* This result is in conformity with the findings of Limoee et al. (2001), Robison et al. (1999) and Enayati et al. (2007), who revealed that Cypermethrin was more effective than Deltamethrin (Deltamethrin) in the control of *B. germanica.* In a research carried out by Shahi et al. (2008) toxicity of cypermethrin, deltamethrin, diazinon, lambda-cyhalothrin and Negon® (permethrin+propoxur) commercial formulations were investigated against adult German cockroaches collected in different areas of Bandar Abbas City, southern Iran. Maximum mortality rates of 20, 35, 90 and 100% were obtained after one

**Table 10.** Lethal time values for Chlorpyrifos (initial).

| Lethal time | Aqueous | | | | Diesel | | | |
|---|---|---|---|---|---|---|---|---|
| | 2.5% (v/v) | | 5% (v/v) | | 52.% (v/v) | | 5% (v/v) | |
| | $I_O$ | $I_C$ | $I_O$ | $I_C$ | $I_O$ | $I_C$ | $I_O$ | $I_C$ |
| $LT_5$ (minutes) | 12 | 13 | 13 | 5 | 1 | 1 | 3 | 2 |
| $LT_{50}$ (minutes) | 25 | 24 | 37 | 15 | 10 | 7 | 12 | 6 |
| $LT_{95}$ (minutes) | 54 | 43 | 105 | 47 | 85 | 36 | 46 | 26 |

hour contact with label-recommended doses of cypermethrin, deltamethrin, lambad-cyhalothrin, diazinon and permethrin+propoxur insecticides, respectively. This result is not in conformity with other researches done on the *B*. *germanica* using cypermethrin and deltamethrin, as higher mortality was recorded using Deltamethrin than in Cypermethrin. The findings however, of Shahi et al. (2008) on the effects of both insecticides on *B*. *germanica*, as well as those of Spring (2010) and Cakir et al. (2008) on other insect pests revealed that Cypermethrin was more effective than Deltamethrin.

This study also revealed that fumigation treatments were more effective than dis-infestation treatments in the control of *B. germanica*. The results on the residual effect (one and two weeks respectively) of Chlorpyrifos and Deltamethrin were in conformity with the findings of Enayati et al. (2007) and Spring (2010).

Results from this study revealed a higher insecticidal effect of Chlorpyrifos over Deltamethrin (for both fumigation and disinfestation) against *B. germanica. Chlorpyrifos* had a faster knock down effect and higher percentage mortality than Deltamethrin, and this was observed for both concentrations and diluents used for the study. The importance of this finding implies that Chlorpyrifos (organophosphate) insecticides may be adopted for the control of *B. germanica* within Lagos metropolis. The diesel-diluted treatments were more effective than aqueous treatment for both insecticides. The residual properties of both insecticides followed a similar trend observed in initial exposure. The mortality response was however relatively low (<40%) for both insecticides at the maximum time lapse of two weeks. This implies that both insecticidal agents will perhaps become ineffective over a 2-week duration, hence the need to reapply these chemicals when necessary. Ultimately, the sustainable control of *B. germanica* in the long-term will involve various approaches in an integrated manner in order to safeguard the ecosystem for other organisms.

## Conflict of Interests

The author(s) have not declared any conflict of interests.

### REFERENCES


Batth SS (1977). A survey of Canadian populations of the German cockroach for resistance to insecticides. Canadian Entomol. 109: 49-52.

Cakir G, Yavuz O, Kocak O (2008). Effects of Piperonyl Butoxide and Tetramethrin Combinations on Biological Activities of Selected Synthetic Pyrethroid Insecticides against Different Housefly (*Musca domestica L., Diptera*: *Muscidae*) Populations. Acta Vet. Brno. 77:467-474.

Chapman PA, Learmount J, Pinniger DB (1993). Insecticides resistance in *Blattella* (L.) in the United Kingdom. (Widley KB and Robinson WH, eds.) Proceedings of the First Int Conf. Insect Pests Urban Environ. 19:125-133.

Cochran DG (1994). Abamectin resistance potential in the German cockroach (*Dictyoptera*: *Blattidae*). J. Econ Entomol. 87:899-903.

Cochran DG (1995). Insecticides resistance. In Understanding and Controlling German Cockroach, (Rust MK, Owens JM and Reierson DA, eds.). New York, Oxford University Press. 3:171-192.

Enayati AA, Fazard MH (2007). Biochemistry of pyrethroid resistance in German cockroach (*Dictyoptera*: *Blattelidae*) from hospitals of Sari, Iran. Iran. Biomed. J. 11(4):251-258.

Engelmann F (1970). The Physiology of Insect Reproduction. Pergamon Press. 307p.

Fasulo TR (2002). Stored Product Pests and German cockroach. Bug Tutorials. University of Florida/IFAS. CD-ROM. SW-165.

Heal RE, Nash KB, Williams M (1953). An insecticides resistant strain of the German cockroach, Corpus Christi, Texas. J. Econ. Entomol. 46: 385-386.

Jacobs S (2007). German Cockroaches (On –line). Entomology notes, Pennsylvania State University. http://www.ento.psu.edu/extension/factsheet/german cockroach.htm

Limoee M, Enayati AA, Khassi K, Salami M, Ladoni H (2001). Insecticide reisitance and synergism of three field collected strains of the German cockroach, *Blatella* (L) (*Dictyoptera*: *Blatellidae*) from hospitals in Kermanshah, Iran. Trop. Biomed. 28(1): 111-118.

Roth LM (1970). The stimuli regulating reproduction in cockroaches. Centre National de la Recherche Scientifique 189: 267–286.

Rust MK, Owens JM, Reierson DA (1995). Understanding and Controlling the German Cockroach. Oxford University Press. 448p.

Rust MK, Reierson DA (1991). Chlorpyrifos resistance in German cockroaches (*Dictyoptera: Blattidae*) from resturants. J. Econ. Entomol. 84:736-740.

Schal C (1992). Sulfluramid resistance and vapor toxicity in field collected German cockroaches (*Dictyoptera*: *Blattellidae*). J. Med. Entomol. 29: 207- 215.

Shahi M, Hanafi-Bojd AA, Vatandoost H (2008).Evaluation of Five Local Formulated Insecticides against German Cockroach (*Blattella* L.) in Southern Iran. Iran. J. Arthropod-Borne Dis. 2(1):21-27.

Silverman J, Ross MH (1994). Behavioral resistance of field- collected German cockroaches (*Blattodea*: *Blattellidae*) to baits containing glucose. Environ. Entomol. 23:425- 430.

Spring AB (2010). Susceptibility of *Anopheles species* populations collected from four localities in Juba County to DDT and deltamethrin, Central Equatoria State, Southern Sudan. Resistant Pest Manag Newsletter 19(2): 230-256.

Umeda K, Yano T, Hirano M (1988). Pyrethroid- resistance mechanism in German cockroach, *Blattella* (*Orthoptera*: *Blattidae*). Appl. Entomol. Zool. 23:373- 380.

Zhai J, Robinson WH (1991). Pyrethroid- resistance in a field population of German cockroach, *Blattella* (L.). Jpn. J. Sanitary Zool. 42: 241-244.