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Research Article

Comparative studies of the efficacy and mode of action of Cypermethrin, Chlorpyrifos and 'Tofeto' against *Periplaneta americana* (*L*) (Dictyoptera: Blattodea)

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Abstract

The American cockroach, *Periplaneta americana*, is an invasive household pest posing significant public health threats and contributing to home allergen issues. Management is necessary due to its economic and health impacts. Several studies have reported that American cockroaches demonstrate tolerance to certain commercial insecticides, potentially due to physiological factors or specific modes of insecticide application. This study assessed the toxicity of a locally sold insecticide, 'Tofeto', and two conventional commercial insecticides, chlorpyrifos and cypermethrin, on adult *Periplaneta americana*. Efficacy was evaluated by comparing knockdown time (KT_{100}) and lethality time (LT_{100}) following both topical and injection applications. Data were analyzed using one-way Analysis of Variance (ANOVA) and Fisher's Least Significant Difference (LSD) test. 'Tofeto' was identified as the most efficient knockdown agent in both sexes of roaches, regardless of application method. The order of effectiveness observed was Tofeto > cypermethrin > chlorpyrifos. Cypermethrin resulted in quicker lethality via injection. Both injection and topical assays indicated that the cuticular barrier influenced insecticide effectiveness, as KT_{100} was reduced by 6-79 folds and LT_{100} by 3-95 folds. Across all assays, 'Tofeto' was more effective as knockdown and mortality insecticide than cypermethrin and chlorpyrifos. Therefore 'Tofeto' is recommended for the control of cochroaches at home.

Keywords: *Periplaneta americana*, Cypermethrin, Chlorpyrifos, Tofeto, Toxicity

1. Introduction

Cockroaches are the most abundant and obnoxious insect pests in residential buildings, hospitals, hotels, and restaurants (Zaharaci-Ramazani *et al*, 2018; Abdullah & Majid, 2023) that subsist on human wastes (Yahaya & clement, 2010). They produce an offensive characteristics smell (Atiokeng-Tatang *et al*, 2017), and transmit disease organisms such as bacteria, parasitic worms, and other human pathogens (Oriolowo *et al*, 2025). Exposure to cockroach antigens may play an important role in asthma-related problems in humans (Ozoh & Bamidele, 2012; Schal & DeVries, 2021). There has been an unprecedented increase in cockroach populations in public places and residential apartments worldwide (Dong-Kyu, 1995; Katrup, 2003, 2004; Ghosh & Gayen, 2006; El-Sherbini and El-Sherbini, 2011). In Nigeria, they are abundant in most homes (Bala and Sule, 2012; Wahidi *et al.*, 2020; Etinosa *et al.*, 2022), but the severity of their health risk to man is yet to be fully appreciated (Omudu and Enyumah, 2008; Adenusi *et al*, 2018). However, the desire to control them remains alive and evolving.

Chemical insecticides remain the most utilized in cockroach pest management, and this employs a myriad of insecticides under different names. The efficacy of these insecticides is determined by the biomass, sex, and physiological status of cockroaches (Appel *et al*, 1983; Wakil *et al*, 2012; Moemenbellah *et al*, 2013), and methods of application (Shashi *et al*, 2008; Agrawal *et al*, 2010). In Nigeria, most people have embraced the use of chemical insecticides because of their promptness, efficacy, and ease of application, despite the associated risks. Recently, a number of chemical dilutions of obscured scientific details are sold to the public for the control of household insect pests in Nigeria. One such chemicals is 'Tofeto', whose mode of action and efficacy has not been reported. However, it is commonly used because it is relatively cheap and affordable.

This study aims to precisely compare the efficacy and modes of action of 'Tofeto' with two established blatticides, Chloryprisfos and Cypermethrin, against the American

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cockroach, *Periplaneta americana*.

2. Materials and methods

2.1. Insects culture

Twenty (20) males and female's adult cockroaches, *Periplaneta americana* (*L*) were collected from a residential building in Ilorin (Longitudes 4° 30' and 4° 45' E and Latitude 8° 25' and 8° 40' N) Kwara State, Nigeria. This culture was maintained in the Zoology Department Laboratory, University of Ilorin, Ilorin, Nigeria, under ambient temperature and humidity and fed with pulverized biscuit and water. They were allowed to mate, lay eggs and the subcultures from individual cocoon were reared to the adult stage. In all cases, 7 months old sexed adult cockroaches were used for each experiment.

2.2. Chemical insecticides

Two synthetic insecticides, cypermethrin (Supermethrin), a pyrethroid (100 g/L), and chlorpyrifos (Pyrenex), an organophosphate (480 g/L), distributed by Osi Agro-industry chemical co. limited, A 215 Moh'd Adubakarbrini market, Kano, Nigeria, and Disenyoff West Africa Limited, 28 Creek Road, Apapa Lagos Nigeria respectively, were procured from an Agrochemical store along Muritala Mohammed road Ilorin, Kwara State. Tofeto, a new addition to the list of insecticides whose dilution and chemical properties are unknown, was procured from a local hawker along Offa road Ilorin.

2.3. Injection Assay

One hundred and twenty (120) sexed adult cockroaches were weighed and injected with 0.1 mL containing a dose of 1.0 µg/g of the body mass of the test insecticide, using a hypodermal syringe as described by Bell (1980). After treatment, the cockroaches were placed in a group of ten in a transparent plastic box (40 cm × 40 cm × 40 cm) where food and water were supplied. The cockroaches in each box were placed under surveillance for knockdown, mortality, tremor, and wing flecking. Four replicates were set for each test insecticide. The average time to produce 100% knockdown (KT_{100}) and 100% lethality (LT_{100}) was noted and recorded for each test insecticide and sex.

2.4. Contact Assay

One hundred and twenty (120) sexed adult cockroaches received topical application of 0.1_mL of insecticide at a dose of 1.0 µg/g of the body mass just behind the thoracic shield. After treatment, the cockroaches were placed in groups of tens in a transparent plastic box (40 cm x 40 cm x 40 cm) where food and water were supplied. Each treatment group was subsequently monitored for 100% Knockdown time (KT_{100}), period between the application time and the time of irreversible summersault of all the treated cockroaches, 100% lethality (LT_{100}), period between the time of application and the complete immobilization of all the treated cockroaches as described by Tunaz *et al*. (2009).

2.5. Data Analysis

Knockdown Time (KT_{100}) and lethality Time (LT_{100}) data were analysed using one-way Analysis of Variance (ANOVA) and Student's T-test at 5% level of probability, while the means were compared using Fisher's Least Significant Difference (LSD) statistical package for social scientist (SPSS) version 20.

3. Results

Table 1 shows the mean biomass of male and female cockroaches before exposure to various insecticide treatments. The biomass of males and females ranged between 0.61 g to 1.25 g and 0.99 g to 1.67 g, respectively. The overall mean biomass of males was 0.97 ± 0.13 g, while females was 1.34 ± 0.24 g. The mean biomass per treatments per sex was not significantly different ($P< 0.05$); the male cockroaches were significantly smaller ($P>0.05$) than the females, and they have a relatively uniform biomass distribution

Table 1: Average mass (g) of Adult Cockroaches used for the Assays

Sex	Chloryrifos	Cypermethrin	'Tofeto'
Males	0.99 ± 0.12^a	0.91 ± 0.22^a	1.03 ± 0.05^a
Females	1.30 ± 0.34^b	1.42 ± 0.30^b	1.31 ± 0.09^b

Means within the same column followed by the same superscripts are not significantly different ($P \geq 0.05$)

Table 2 shows Knockdown Time (K_{T100}) under all insecticide injections. The male cockroaches showed relatively lower KT100, which implied that they were more susceptible to insecticide treatments than the females. These values were significantly different ($P<0.05$) across sexes and types of insecticide treatments. 'Tofeto' was the most effective, with significantly lower KT_{100} values of 0.03 ± 0.00 and 0.04 ± 0.00, respectively, for males and females. Chlorpyrifos was least effective, with KT_{100} of 0.66 ± 0.24 and 1.20 ± 0.18 respectively for males and females.

Table 2. Average 100% Knockdown Time of Adult Cockroaches exposed to injection Assay

Insecticides	Male	Female
Chloryfos	0.66 ± 0.24^a	1.30 ± 0.18^a
Cypermethrin	0.06 ± 0.00^b	0.47 ± 0.06^b
'Tofeto'	0.03 ± 0.00^c	0.04 ± 0.00^c

Means in the same column followed by the same superscripts are not significantly different ($P<0.05$)

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Table 3 shows the result of 100% lethality Time (LT100) under all insecticide injections. Male cockroaches also showed significantly lower LT_{100}, which implied they died earlier under this insecticide treatment. Cockroaches under cypermethrin injection died earlier with times of 4.20 ± 1.80 and 12.0 ± 7.80, respectively, for males and females; but this was not significantly different (P<0.05) from males under 'Tofeto' treatment.

Table 3. Average 100% Lethality Time (Min) of Adult Cockroaches exposed to injection Assay

Insecticides	Male	Female
Chloryfos	111.00 ± 70.80^{a}	158.40 ± 35.40^{a}
Cypermethrin	4.20 ± 01.80^{b}	12.00 ± 07.80^{b}
'Tofeto'	4.44 ± 06.60^{b}	45.00 ± 22.80^{c}

Means within the same column followed by the same superscripts are not significantly different (P≥0.05)

Table 4 shows that all topically treated cockroaches experienced absolute knockdown and lethality (death) Female roaches took significantly longer time (P<0.05) to achieve 100% Knockdown and lethality. The result also showed that 'Tofeto' was the most potent with significant lower KT_{100} of 0.66 ± 0.36 and 1.92 ± 1.14 for male and female respectively. It also recorded significantly the least LT_{100} of 133.80 ± 9.60 and 164.40 ± 16.80, respectively, for male and female roaches.

Table 4. Average 100% Knockdown and Lethality Time of cockroaches exposed to Topical treatment

	KT_{100} (Min)		LT_{100} (Min)	
Insecticide	Male	Female	Male	Female
Chloryfos	4.98 ± 1.14^{a}	7.20 ± 2.10^{a}	357.00 ± 151.80^{a}	1453.20 ±366.00^{a}
Cypermethrin	4.74 ± 0.00^{a}	10.80 ± 4.02^{b}	136.90 ± 15.00^{b}	1147.80 ± 17.80^{b}
'Tofeto'	0.66 ± 0.36^{b}	1.92 ± 1.14^{b}	133.80 ± 9.60^{b}	164.40 ± 16.80^{c}

Means within the same column followed by the same superscripts are not significantly different (P≥0.05)

4. Discussion

Males of cockroaches used for these bioassays were significantly smaller in body mass than their female counterparts. This is consistent with the findings of Joda *et al.* (2023) where they found male adult *Periplaneta americana* to be smaller in weight, body length, and body width. Successful control of cockroaches depends on the toxicity and the mode of application of the insecticide used (Sheshi *et al*, 2008). Knockdown results revealed 'Tofeto' to be the most potent against cockroaches irrespective of sex and mode of application, while chlorpyrifos was the least knockdown agent. The lethality period was faster in 'Tofeto'-treated cockroaches, with the exception of those administered through injection. However, there was no significant difference in lethality time in cypermethrin and 'Tofeto' when both were injected into cockroaches. Insecticide toxicity occurred earlier in males than in females. This implies that females are more tolerant to insecticides than males. This result is similar to the findings of Schleier & Peterson (2011) and *Quan et al*. (2010), however, this differs from the findings of Abdullah & Majid (2023), who reported adult females to be more susceptible than males. This, according to Appel *et al*. (1983), is attributed to the differences in size between males and females. The males have relatively homogenous physiological makeup and weights compared to the females. The range of size standard deviations of 0.09-0.34 in females compared to 0.05-0.22 in males confirmed this higher size fluctuation in cockroaches used for the present assays. Kaakeh & Benneth (1999) attributed this weight fluctuation in females to the different stages in their reproductive cycle.

Injection of insecticides produced higher toxicity than topical application. Knockdown time was reduced between 6-79 folds while lethality was reduced between 3-95 folds. This confirmed the submission of Siegfried & Scott (1999), and Liu (2012) that insecticide effectiveness or tolerance can

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be influenced by the insects' cuticular barrier. However, this does not affect the order of knockdown and lethality effectiveness of the insecticides used in this study, as 'Tofeto' remained the most potent, while chlorpyrifos was the least potent.

5. Conclusion

These tested insecticides were found to be effective against cockroaches. Their effectiveness was influenced by the sex of the cochroaches and the methods of application employed. 'Tofeto' was however more effective than cypermethrin as knockdown insecticide against cochroaches. It has the ability to quickly render the insect uncoordinated, thereby limiting the damage or havoc they would have inflicted. All tested insecticides are therefore recommended for the control of cockroaches within and around our households.

Abbreviations

KT_{100}: Average 100% Knockdown Time of adult cockroach
LT_{100}: Average 100% Lethality Time of adult cocroach

Author Contributions

O.B. Oriolowo: Conceptualization and design, methodology, investigation, data curation and analysis, writing of original draft of manuscript.
A. T. Ande: Supervision, Writing-review and editing of manuscript.

Conflicts of Interest

The authors declare that they have no known conflict of interest.

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