E-ISSN: 1115 – 831X P-ISSN: 3027-2963
MPRI-JAVS | INTERNATIONAL JOURNAL OF AGRICULTURAL AND VETERINARY SCIENCE
VOL. 05 NO. 1 - JULY, 2024

SUSCEPTIBILITY OF ADULT FEMALE *CULEX QUINQUEFASCIATUS* TO PYRETHROID (LAMBDACYHALOTHRIN) AND CARBAMATE (BENDIOCARB) AROUND ZARIA METROPOLIS OF KADUNA STATE

[1]KANA, Y.I.; [2]ABUBAKAR, B.S.; & [3]MOHAMMED, M.

[1]Department of Zoology, Ahmadu Bello University, Zaria. [2]Department of Zoology, Nasarawa State University Keffi. [3]Department of Biological Sciences, Federal University Gusau.

Corresponding Author:
bashiruabubakarshafa@gmail.com

Keywords:
Bendiocarb, *Culex quinquefasciatus*, Lambdacyhalothrin, Mosquito, Insecticide, Resistance.

Abstract

The study was carried out to determine the susceptibility of adult female *Culex quinquefasciatus* to Bendiocarb and Lambdacyhalothrin in Zaria. Immature stages (larva and pupa) of *C. quinquefasciatius* were collected from Samaru, Basawa and Galma Dam between July to September, 2019 using the scooping method. The immatured stages were reared to adult in the laboratory and exposed to Bendiocarb (0.05%) and Lambdacyhalothrin (0.1%) using the standard WHO standard procedures and test kits for adult mosquitoes to test for their susceptibility status. WHO standards for characterizing insecticide resistance and susceptibility where susceptibility is defined by mortality rate greater than 98% after 24 hours post exposure and a mortality of less than 98% is suggestive of the existence of resistance is used for the determination of susceptibility and resistance and t-test was used to compare susceptibility between Bendiocarb and Lambdacyhalothrin across each location. The highest mortality was recorded after 60mins of exposure to Bendiocarb while *C. quinquefasciatus* was resistant to Lambdacyhalothrin at the 24 hours post exposure period. There was significant difference in the mortality of *C. quinquefasciatus* exposed to both insecticides; however, there was no

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significant difference after 15mins of exposure in Basawa. This study has highlighted the susceptibility of C. quinquefasciatus Bendiocarb and resistant to Lambdacyhalothrin which could be as a result of long time use of Pyrethroid as agrochemicals and in public health uses in Indoor Residual Spray and impregnated into Long Lasting Insecticidal Nets (LLINs). Rational but control use of insecticide should be developed to prolong and delay resistance development in local mosquito species of Zaria.

Introduction

Mosquitoes are important, obnoxious, and notorious blood-sucking insect pests that have been ravaging human populations through the transmission of several dreadful tropical diseases, including malaria, filariasis, yellow fever, and other arboviruses, causing critical health challenges to humans (Nwosu *et al*., 2011). Mosquito-borne diseases greatly affect public health and contribute significantly to disease burden, causing high morbidity and mortality in human and animal populations and leading to huge economic losses and developmental problems worldwide (Andeas, 2014; Pal, 2014). The females' biting habit during their search for a blood meal shortly before oviposition increases their propensity to transmit various diseases associated with high morbidity and mortality (Afolabi *et al*., 2013). Additionally, they cause biting annoyance, noise nuisance, sleeplessness, and allergic reactions (Andeas, 2014).

One of the approaches for the control of mosquito-borne diseases is the interruption of disease transmission by killing or preventing mosquitoes from biting humans and animals (Egunyomi *et al*., 2010; Queen *et al*., 2014). Vector control using insecticides remains an important component of many vector-borne disease control programs and relies heavily on Insecticide Residual Sprays (IRS) and Long-Lasting Insecticide Nets (LLINs) to target endophilic and endophagic vector mosquitoes, respectively (Andeas, 2014). However, the ubiquitous use of a limited number of insecticides for both agricultural pests and vectors of human and livestock diseases has led to widespread resistance (Djogbenou, 2009). This development reduces the efficacy of LLINs and IRS, which constitute the main tools of vector control, thereby making insecticides ineffective and limiting the available options for disease control (Rivero, 2010). Insecticide resistance is expected to directly and profoundly affect the reemergence of vector-borne diseases, and where resistance has not contributed to disease emergence, it is expected to threaten disease control (Nwabor *et al*., 2015).

According to WHO (2013), if nothing is done about insecticide resistance, it could eventually result in the widespread failure of pyrethroids, leading to devastating public health consequences. Therefore, the successful implementation of IRS and LLIN programs partly depends on increasing the monitoring of insecticide resistance to guide

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mitigation and management strategies for vector control of mosquitoes in the local environment. It is imperative to periodically conduct bioassay tests to assess the susceptibility status of local mosquito species to IRS interventional insecticides. Along this line, this study is part of the insecticide resistance monitoring framework and aims to assess insecticide susceptibility and resistance of Culex mosquitoes in varying locations of Zaria, Nigeria.

MATERIALS AND METHODS

Study Area

This study was carried out in Zaria metropolis of Kaduna state. Zaria is located between latitude 11°4"North and Longitude 7°42"East situated at elevation 644 above sea level. Zaria belongs to the tropical continent climate characterized by distinct wet seasons that occurs between April and October, and dry seasons that occur between November and April, with annual rainfall reaching up to 43.0 inches (Usman, 2007). Zaria is region characterized by mainly open woodland vegetation (Hore, 1970).

Mosquito Larval Sampling

Immature stages (larvae and pupae) of *Culex quinquefasciatus* were collected from Samaru, Basawa, and Galma Dam between July and September 2019 using the scooping method. The collected Culex mosquito larvae were transported in well-labeled plastic containers to the Department of Zoology Laboratory at Ahmadu Bello University (ABU), Zaria, where they were maintained and reared for World Health Organization (WHO) bioassays. In the laboratory, the larvae were fed with a mash made from 10 tablets of yeast and biscuits, while the adult mosquitoes were provided with a 10% sugar solution. The resulting adults were identified based on the morphological keys provided by Gillies and Coetzee (1987).

WHO Susceptibility Testing

Insecticide susceptibility tests were carried out using the WHO standard procedures and test kits for adult mosquitoes (WHO, 2013). Two types of WHO bioassay test papers impregnated with recommended diagnostic concentrations of 0.1% Lambdacyhalothrin (Pyrethroid) and 0.05% Bendiocarb (Carbamate) were used. Tests were conducted on three-day-old, sugar-fed female *Culex* mosquitoes. A maximum of 80 female mosquitoes, divided into four replicates, were tested for each insecticide (WHO, 2013).

Data Analysis

Mortalities were expressed as percentages (Table 1). The control tube mortality rate was less than 5%, implying no any Abbott's correction (Abott, 1987). The susceptibility and

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resistance status of *C. quinquefasciatus* was determine according to WHO standards while The Knock down data (KDT_{50} and KDT_{95}) was subjected to Probit Analysis using hand calculation (Finney and Stevens 1948). (Table 2). Analysis of Variance (ANOVA) was used to compare the mortalities of the two insecticides across the sampling locations and Duncan Multiple Range Test (DMRT) was used to separate the means.

RESULTS

The WHO bioassay of *Culex quinquefasciatus* conducted with the two insecticides across the three sampling sites revealed the percentage mortality recorded after a 24-hour post-exposure period. According to the susceptibility tests conducted, the mortalities generated by each insecticide showed variations at different sites assessed. For Bendiocarb, the knockdown exposure time was 40 minutes with 100% mortality in Samaru, and 60 minutes with 100% mortality in Basawa and Galma Dam (Table 4.1). This indicates complete susceptibility to Bendiocarb in all locations. In contrast, the tests showed that the mosquitoes developed resistance to Lambdacyhalothrin, with recorded exposure mortality rates 24 hours post-exposure period as follows: Samaru (78.75%), Basawa (72.50%), and Galma Dam (73.75%) (Table 4.2). This indicates a lower effectiveness of Lambdacyhalothrin compared to Bendiocarb across the three sites. WHO susceptibility bioassays for all three months to Lambdacyhalothrin and Bendiocarb showed that exposure mortality rates recorded across the three sampling locations differed significantly ($P<0.05$) (Tables 4.3, 4.4, and 4.5). During the knockdown assessment for *C. quinquefasciatus* using Bendiocarb, the highest KDT50 (knockdown time for 50% of mosquitoes) was recorded in Galma Dam at 42 minutes, followed by Basawa at 34 minutes, and Samaru with the least at 18 minutes (Table 2). There was a significant difference ($P<0.05$) between the KDT50 values of Bendiocarb and Lambdacyhalothrin when compared across the three sampling sites, indicating varied levels of resistance and susceptibility among the mosquito populations in these locations.

Table 1: Mortalities Of *Culex quinquefasciatus* after 1hr exposure to 0.05% Bendiocarb and 0.1% Lamdacyhalothrin in Samarau, Basawa and Galma Dam, Zaria.

Location	Insecticide	Exposure Mortality							
Samaru	Bendiocarb	0.00^a	7.50^a	28.75^a	86.25^a	100^a	100^a	100^a	100^a
	Lambdacyhalothrin	0.00^a	0.00^a	0.00^b	0.00^b	1.25^b	3.57^b	6.25^b	12.50^b
Basawa	Bendiocarb	0.00^a	0.00^a	3.75^a	16.25^a	21.25^a	28.75^a	42.50^a	100^a
	Lambdacyhalothrin	0.00^a	0.00^a	0.00^a	0.00b	13.75^a	2.50^b	3.75^b	15.00^b
Galma Dam	Bendiocarb	0.00^a	0.00^a	0.00^a	62.5^a	1.25^b	26.25^a	50.00^a	92.50^a
	Lambdacyhalothrin	0.00^a	0.00^a	0.00^a	0.00^a		2.50^b	3.75^b	10.00^b

Values are Means ±SD, Values with same superscript across the rows are not significantly different ($P>0.05$) using Duncan Multiple range test (DMRT

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Table 2: 24hours Post Exposure Mortality and KDT_{50} and KDT_{95} after 1hour Exposure to Bendiocarb and Lambdacyhalothrin

Location	Insecticiede	24hours Post exposure mortality (%)	KDT_{50} (min)	KDT_{95} (min)
Samaru	Bendiocarb	100	18^a	68^b
	Lambdacyhalothrin	78.75	96^a	794^b
Basawa	Bendiocarb	100	34^a	135^b
	Lambdacyhalothrin	72.50	123^a	794^b
Galma Dam	Bendiocarb	100	42^a	158^b
	Lambdacyhalothrin	73.75	104^a	794^b

Figures with same letters in columns are not significantly different (P>0.05)

DISCUSSION

The study on *Culex quinquefasciatus* in Zaria, Nigeria, indicated susceptibility to Bendiocarb, a carbamate insecticide, after varied times of exposure, while a marked resistance was observed to the pyrethroid class of insecticides. This resistance pattern correlates with findings by Ukpai and Ekedo (2018) in Umudike, Abia, who reported a low toxicity response of C. quinquefasciatus populations to pyrethroids. This resistance could potentially be attributed to the use of the same active chemical ingredients in both agricultural and public health insecticides, as suggested by Chouaibou (2016). The widespread use of similar agrochemicals may exert significant selection pressure on mosquito populations, leading to increased resistance.

The knockdown effect observed in the adult female *C. quinquefasciatus* by the tested insecticidal papers suggests that knockdown resistance mechanisms (KDR) could be present in the local mosquito populations in Zaria. This aligns with previous studies documenting the knockdown effects of impregnated papers against mosquitoes in Nigeria (Awolola *et al*., 2005; 2007; Oduola *et al*., 2010; Olayemi *et al*., 2011; Ibrahim *et al*., 2014; Umar *et al*., 2014). Such knockdown of mosquitoes exposed to insecticidal papers indicates the potential operation of KDR mechanisms in these populations, which could account for the observed level of resistance to the tested insecticides.

Furthermore, the study raises concerns about the potential cross-resistance in *Anopheles* mosquitoes, which often coexist with Culex species. This sympatry could jeopardize the efficacy of vector control strategies such as Indoor Residual Spraying (IRS) and Insecticide-Treated Nets (ITNs), especially if resistance spreads between these genera (Awolola *et al*., 2008; Umar *et al*., 2014). Additionally, the frequent use of pyrethroid-based aerosols and coils for the control of mosquitoes and other domestic pests might further contribute to the development of resistance, as noted in other studies (Kristan *et al*., 2003).

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The observed resistance in *C. quinquefasciatus* to pyrethroid and carbamate insecticides in Zaria underscores the urgent need for diversified vector control approaches and the implementation of resistance management strategies to sustain the effectiveness of current mosquito control programs.

CONCLUSION

This investigation highlighted the susceptibility of *Culex* mosquitoes to Bendiocarb, with 100% exposure mortality across all sampled sites, and resistance to Lambdacyhalothrin, with recorded exposure mortalities of 79% in Samaru, 73% in Basawa, and 74% in Galma Dam. The observed resistance to Lambdacyhalothrin in *Culex* mosquitoes raises significant concerns for national mosquito control programs. This study also reveals a low insecticidal effects of Lambdacyhalothrin and a high insecticidal effect of Bendiocarb comparably in the three samples locations. Due to the high resistance to pyrethroids and DDT, these programs are currently introducing Bendiocarb-based IRS for mosquito control in West African countries (Djouaka *et al*., 2011).

RECOMMENDATION

Rational but controlled use of insecticides should be developed to prolong and delay resistance development in local mosquito species of Zaria. Integrated vector management at the community level should be encouraged, and proper sensitization of the populace should be embarked upon, especially before, during, and after the onset of rainfall, to reduce the recurrent cases of mosquito-transmitted diseases.

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