Permethrin Insecticide Susceptibility Status of Mosquito Vectors in Minna, Niger State Capital

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Abstract

Insecticides play a vital role in the control of mosquito vectors and will continue to do so for the foreseeable feature. This study is therefore carried out to determine the level of resistance of mosquito vectors in Minna to permethrin insecticide. Mosquito larvae were collected and reared to adult from major conventional mosquito breeding habitats in five (5) selected areas of Minna (Bosso, Chanchaga, Gidan Mangoro, Maitunbi and Maikunkele). The adults from the different conventional breeding habitats in each of the areas were pooled together and subjected to CDC bottle bioassay using permethrin (0.75%) insecticide. The result showed that all the 3 genera of mosquito sampled in this study showed considerable resistance to permethrin (0.75%) insecticide. *Anopheles* mosquito showed the highest resistance to permethrin (0.75%) with average resistance of 15%, followed by *Culex* with 39.30% while *Aedes* mosquito had the least resistance (62.78%) to permethrin (0.75%) insecticide. All the areas have their *Anopheles* Mosquitoes to be resistant to permethrim (0.75%). However, among the 5 areas, Maikunkele had the highest susceptibility with the percentage mortality of 19%.This is followed by Gidan Mangoro with 18% mortality. All the *Aedes* Mosquitoes groups encountered in the five (5) study areas showed varying level of susceptibility which ranges from 50% mortality has observed in Gidan Mangoro to 78.33% mortality has observed in Bosso area. Among the 5 areas, Gidan Mangoro had the highest susceptibility with 47% mortality. This is followed by Bosso Area with 42% mortality. Meanwhile, Maitumbi is the least susceptible with 33% mortality. The result obtained from this study has indicated that all the mosquito vectors in Minna have shown considerable resistance to permethrin which is one of the major insecticides used in the area. This therefore, calls for urgent intervention in order to forestall the outbreak of mosquito-borne diseases in Minna.
Key Words: Permethrin, Susceptibility, Resistance, Mosquito and Mortality

INTRODUCTION

Mosquitoes are thin, long-legged, two-winged insects and are typically six to 12 millimetres in length of which both males and females have antennae and an elongated "beak" or proboscis three to four times longer than it’s head. These insects belong to the Diptera order, known as the true flies, in the family Culicidae. All true flies have two wings; however, mosquitoes are the only true flies to have scaled wings (Aynsley, 2007).

Insecticides play a vital role in the control of mosquito vectors and will continue to do so for the foreseeable feature. However, the ubiquitous use of a limited number of insecticides for both agricultural pests and vector of human and livestock diseases has led to resistance, making insecticides used ineffective and limiting the available option for disease control (Rivero *et al*., 2010). Vector borne diseases are among the major causes of illness and death, particularly in tropical and subtropical countries; vector control through the use of insecticide plays a key role in the prevention and control of infectious diseases (Rivero *et al*., 2010). In Nigeria, mosquitoes are regarded as public health enemies because of their biting annoyance and noise nuisance, sleeplessness, allergic reaction and disease transmission due to their bites (Wilson *et al*., 2013; Kumar *et al*., 2014). All these diseases cause great suffering to man and livestock. They do not only cause high morbidity and mortality in human and animal population, but also lead to huge economic losses (Onyido *et al*., 2009; Pal *et al*., 2014). One of the approaches for the control of these mosquito borne diseases is the interruption of diseases, transmission by killing or preventing mosquitoes from biting man and animals (Dhivya *et al*., 2013).

Mosquito control remains an important component of human and animal diseases (Djenontin *et al*., 2009; Zofou *et al*., 2014). However, this has been limited by the development and spread of resistance and limited knowledge of mosquito biology (Nantulya *et al*., 2007; Karunamoorthi *et al*., 2013).

Presently, there are 12 insecticides recommended by the WHO insecticide evaluation scheme for indoor residual spraying (IRS) against mosquitoes, out of this only dichloro- diphenyltrichloroethane (DDT) which has the longest residual effect (> 6 months) is not yet used in Nigeria, because of environmental concerns (Coetzee, 2004). The re-introduction of DDT into the mosquito control is expected to produce mosaic defense against the development of resistance (Awolola *et al*., 2007).

Anopheles vector control relies heavily on a single class of insecticides, the pyrethroids. These insecticides are the only class approved for use on insecticide treated nettings (Ranson, 2011) and are being increasingly deployed in Indoor residual spray (IRS) programmes in Africa and Long lasting insecticide treated nets (LLINs) (Ranson, 2011; Wang *et al*., 2015). A rise of pyrethroids resistance by mosquitoes has become the latest threat to combating malaria in Nigeria, where roughly up to 300,000 people die each year from the killer disease (Salihu and Sanni, 2013).

The problem of insecticide resistance is very real and growing in Nigeria (WHO, 2009), there are signs that it might worsen due to the effects of climate change and there is concern that the mosquitoes are becoming resistant to the entire classes of insecticide in use (Kweka *et al*., 2015; Dai, 2015), reported the studies on the distribution of *Anopheles* in Nigeria between 1900 to 2010 as follows; *An. gambiae* s.1 (181),65.2%, *An*.

gambiae s.s (156),6.5%, *An. Arabiensis* (122), 5.0%, *An. funestus* complex (95) 17.3%, *An. funestus* s.s (21), 2.5% while other species (57) constitute 4.5%.

In a related investigation carried out in the Southern part of Nigeria *An. gambiae* s.1 constitutes 77.7% of the total number of mosquitoes caught followed by *An. funestus* 22.3% which confirms it as the most common mosquito in the country (Oyewole, 2005). Knowledge on insecticide resistance in target species is a basic requirement to guide insecticide use in mosquito-borne diseases control programs

The two major causes of insecticide resistance are alterations in the target sites and increase in the rate of insecticide metabolism (Wondji *et al*., 2009). However, the major emphasis on research focuses in molecular mechanisms and rational resistance management with a view of controlling the spread and development of resistance in mosquito population (Amenya, 2005).

Several studies have conducted in Nigeria in order to ascertain the resistance of Mosquito species to insecticides. Oyewole *et al*. (2011) studied the ecological zones in Nigeria on the insecticide resistance and the results showed > 78% susceptibility to the diagnostic concentrations of insecticides (DDT, Permethrin and Deltamethrin) tested. However, not less than 27% of the exposed specimen showed resistance. More than 97% mortality was recorded for samples from mangrove and Sudan savanna when exposed to deltamethrin and DDT respectively.

Also, Mosquito vectors have continued to show resistance to insecticides. This is indeed evident from the ineffectiveness of the pyrethrum impregnated insecticide net. No published paper exist in Minna showing the susceptibility of mosquito vectors to insecticides as well as variation in susceptibility rate due to location.

MATERIALS AND METHODS

Description of Study Area

The study was carried out in Minna, the Capital of Niger State, North Central, Nigeria. The area is located at longitude 6˚ 33’ East and latitude 9° 37’ North; it is surrounded by sedimentary rock, characterized by sandstones and alluvial deposits and granites. Though there are three most pronounced ethnic groups which are Nupe, Gbagyi and Hausa, there are many other groups living happily with one another Kadara, Koro, Barab, Kakanda, GanaGana, Dibo, Kambari, Kamuku, Pangu, Dukawa, Gwada and Ingwai. Tribes like Igbo, Yoruba and numerous others from other States also settled happily in Niger State.

Farming is the dominant occupation of the state. The area has a tropical climate with mean annual temperature, relative humidity and rainfall of 30.200C, 61.00% and 1334.00mm, respectively. The climate presents two distinct seasons; a rainy season between May and October, and a dry season between November and April. The vegetation in the area is typically grass dominated Savannah with scattered trees (Ukubuiwe *et al*., 2012).

Collection and rearing of mosquito larvae

Third to fourth instar larvae and pupae of mosquito larvae were collected from breeding sites in the five areas covered in the study (Bosso, Chanchaga, Gidan Mangoro, Maitunbi and Maikunkele. The collections were done from the tree conventional mosquito breeding habitats selected for this study (Rice Field, Rain Pool and Gutters) during the month of August and September, 2020. The mosquito larvae collected were subsequently transported the insectary of Department of Animal Biology FUT Minna were the larvae were properly sorted in to the Genus *Anopheles*, *Aedes* and *Culex* after which they were subsequently reared to adult. The larvae were fed with granulated yeast tablet. The emerging adult mosquitoes were placed in the adult mosquito cages and fed with 10% sugar solution soaked in cotton wool.

3CDC bottle bioassay method

Twenty to twenty unfed mosquitoes of 3–5 days old were introduced into four 250ml Wheaton bottles coated with Technical grade insecticide (permethrin) and one control bottle coated with acetone. These were provided by Center for Disease Control (CDC), Atlanta Georgia as described by the Guideline for Evaluating Insecticide Resistance in Vectors Using the CDC Bottle Bioassay). The numbers of dead and live mosquitoes were monitored at different time intervals (0, 5, 10, 15, 20, and 25mins). This allowed the determination of the total percent mortality against time for all replicates.

Data Analysis

Percentage mortality to the insecticide for the mosquitoes from each of the study locality were determined. The resistance/susceptibility status of the mosquitoes were evaluated using WHO (1998). Mortality rates

<80% at 30m minutes post exposure indicated resistance, >97% indicated susceptibility and mortality rates between 80 and 97% indicated that resistance is suspected.

RESULTS

Susceptibility of *Anopheles* Mosquitoes Exposed to Permethrin using CDC Bioassay Bottle

Table 4.23 shows the susceptibility of *Anopheles* Mosquitoes exposed to permethrin using CDC Bioassay Bottle. All the *Anopheles* Mosquitoes groups encountered in the five (5) study areas showed low susceptibility to permethrin (0.75%). All the areas have their *Anopheles* Mosquitoes to be resistant to permethrim (0.75%). However, among the 5 areas, Maikunkele had the highest susceptibility with the percentage mortality of 19%.This is followed by Gidan Mangoro with 18% mortality. Meanwhile, Bosso and Maitumbi Areas both had the least susceptibility with 12% mortality.

Table 4.23: Susceptibility of *Anopheles* Mosquitoes Exposed to Permethrin using CDC Bioassay Bottle

Time of Exposure (min.)		**0 minute**		**15 minutes**		**30 minutes**			
Area	**No. of Mosquito Exposed**	**No. Alive**	**No. Dead**	**No. Alive**	**No. Dead**	**No. Alive**	**No. Dead**	**% Mortality**	**Status**
Bosso	100	100	0	98	2	88	12	12%	Resistant
Chanchaga	100	100	0	97	3	86	14	14%	Resistant
G. Mangoro	100	100	0	93	7	82	18	18%	Resistant
Maitunbi	100	100	0	98	2	88	12	12%	Resistant
Maikunkele	100	100	0	98	2	81	19	19%	Resistant
Average								15%	Resitant

Susceptibility of *Aedes* Mosquitoes Exposed to Permethrin using CDC Bioassay Bottle

Table 4.24 shows the susceptibility of *Aedes* Mosquitoes exposed to permethrim using CDC bioassay bottle. All the *Aedes* Mosquitoes groups encountered in the five (5) study areas showed varying level of susceptibility which ranges from 50% mortality has observed in Gidan Mangoro to 78.33% mortality has observed in Bosso area. This mortality observed is an indicative of the resistance of *Aedes* Mosquitoes in these areas to permethrin (0.75%).

Table 4.24: Susceptibility of *Aedes* Mosquitoes Exposed to Permethrin using CDC Bioassay Bottle

Time of Exposure (min.)		**0 minute**		**15 minute**		**30 minute**			
Area	**No. of Mosquito Exposed**	**No. Alive**	**No. Dead**	**No. Alive**	**No. Dead**	**No. Alive**	**No. Dead**	**%Mortality**	**Status**
Bosso	60	60	0	55	5	13	47	78.33%	Resistant
Chanchaga	60	60	0	56	4	24	36	60%	Resistant
G.Mangoro	60	60	0	57	3	30	30	50%	Resistant
Maitumbi	60	45	0	41	4	17	28	62.22%	Resistant
Maikunkele	60	60	0	52	8	22	38	63.33%	Resistant
Average								62.78%	Resistant

Susceptibility of *Culex* Mosquitoes Exposed to Permethrin using CDC Bioassay Bottle

Table 4.25 shows the susceptibility of *Culex* Mosquitoes exposed to permethrin using CDC Bioassay bottle. All the *Culex* Mosquitoes groups encountered in the five (5) study areas showed low susceptibility to permethrin (0.75%). The low susceptibility observed therefore, is an indicative of resistance of *Culex* Mosquitoes in these areas to permethrin. However, among the 5 areas, Gidan Mangoro had the highest susceptibility with 47% mortality. This is followed by Bosso Area with 42% mortality. Meanwhile, Maitumbi is the least susceptible with 33% mortality.

Table 4.25: Susceptibility of *Culex* Mosquitoes Exposed to Permethrin using CDC Bioassay Bottle

Time of Exposure (min.)		0 minute		15 minute		30 minute			
Area	**No. of Mosquito Exposed**	**No. Alive**	**No. Dead**	**No. Alive**	**No. Dead**	**No. Alive**	**No. dead**	**%mortality**	**Status**
Bosso	100	100	0	99	1	58	42	42%	Resistant
Chanchaga	100	100	0	99	1	62	38	38%	Resistant
Gidan Mangoro	100	100	0	98	2	53	47	47%	Resistant
Maitumbi	100	100	0	99	1	67	33	33%	Resistant
Maikunkele	100	100	0	99	1	61	39	39%	Resistant
Average								39.80%	Resistant

DISCUSSION OF RESULTS

Resistance of *Anopheles* mosquitoes to insecticides in Nigeria is on the increase and these has shown that *Anopheles* Species have been able to show continuous resistance to Permethrin in all the geographical zones of Nigeria, but highest levels of resistance were found in the forest savannah, Mosaic and Guinea savanna. For instance, *Anopheles* mosquitoes were observed to be resistant to all the classes of insecticides except organophosphate in Ghana while DDT and Permethrin showed high levels of resistance in Cameroun and Ogun state, Nigeria (Balarebe *et al*., 2015; Djouaka *et al*., 2016; WHO 2016; Atoyebi *et al*., 2020). In this current study, All the *Anopheles* Mosquitoes collected from all the 5 study areas showed considerable resistance to permethrin. The mortality of *Anopheles* Mosquitoes recorded in all the 5 areas were similar to what has been reported by earlier researchers in other part of the country. In Auyo of Jigawa state, susceptibility status of *Anopheles* species siblings to three classes of insecticides such as DDT, Permethrin and Bendiocarb using WHO adult insecticides susceptibility bioassay was observed. The *Anopheles gambiae* were highly resistant to DDT and Permethrin but less resistant to Bendiocarb (Habibu *et al*., 2017). Also, the study conducted by Muhammad *et al*. (2021) on *Anopheles* coluzzii which is the major malaria vector in Niger-Delta of Nigeria revealed that the Port Harcourt *An. coluzzii* population is highly resistant to pyrethroids and DDT. The knockdown rates in permethrin (type I pyrethroid), deltamethrin (type II pyrethroid) and DDT was very low, recorded within the range of 3.3 to the highest of 10%. The considerable resistance of *Anopheles* Mosquitoes observed in all these areas of Minna is suggestive that, there is need for alternative insecticide or synergists in order to ensure the adequate control of this malaria vector.

Although *Culex quinquefasciatus* mosquitoes are predominant in most cities across Sub-Saharan Africa and they are of major epidemiological significance as vectors of important diseases like West Nile Virus and filariasis, little is known about their susceptibility to insecticides. This current study assess the susceptibility of *Culex* Mosquito in Minna to permethrin insecticide. The low susceptibility observed in the study therefore, is an indicative of resistance of *Culex* Mosquitoes in these areas to permethrin. Oduola *et al*. (2016) reported Insecticide resistance of *Cx. quinquefasciatus* mosquitoes in two localities in their study to different insecticides and opined that the resistance could be due to insecticide use either in the form of massively distributed pyrethroid LLINs in the state (Obembe *et al*., 2014) or for crop protection. Interestingly, both *Cx. quinquefaciatus* and *Ae. aegypti* mosquitoes were susceptible to permethrin and DDT in most of the sites, showing perhaps the similar mechanism responsible for both class of insecticide.

Notably, the observed *Cx. quinquefasciatus* resistance profile was actually similar to that of *An. gambiae* populations from this current study, most likely attributed to common insecticidal pressures imposed on both vector species. The current expansion of pyrethroid resistance in *Cx. quinquefasciatus* may have derived from the increased selection pressure induced by the massive deployment of pyrethroid treated nets across the country in conjunction with the use of pyrethroid-based insecticides in agricultural pest control (Talipouo *et al*., 2021)

This current study investigates the susceptibility of *Aedes* Mosquito in Minna to Permethrin insecticide. The result revealed that *Aedes* Mosquito in Minna show resistance to permethrin insecticide though at varying level. This is suggestive that resistance of *Aedes* Mosquitoes in Minna to permethrin is recent development and ongoing as indicated by the varying level of resistance exhibited in the study such that *Aedes* Mosquito in some areas in Minna are relatively showing lower resistance compare to other areas. The onset of *Aedes* Mosquito in the area may therefore be due to the excess or indiscriminate use of pyrethrum insecticides in Minna in a bid to control malaria vector as a means of combating malaria in the state. Jirakanjanakit *et al*. (2007) from their study opined that the use of pyrethroid in impregnated bed-net and for domiciliary spraying for malaria control have been suggested to be responsible for resistant of some *Ae. aegypti* populations to pyrethroid in Thailand. Studies by Ayorinde *et al*. (2014) observed the use of pyrethroid-based mosquito repellent in urban areas of Lagos State. The constant use of this pyrethroid-based repellent could also have contributed to resistance to pyrethroid suspected in the nonfarm site of Lagos State. While some previous studies have reported susceptibility of *Ae*. *aegypti* to permethrin in urban areas of Nigeria and Senegal (Ndams *et al*., 2006; Dia *et al*. 2012; Kemabonta *et al*. 2013). Other studies have reported resistance of populations of *Ae*. *aegypti* in other parts of the world (Prapanthadara *et al*., 2002; Srisawat *et al*., 2012). *Ae*. *aegypti* mosquito susceptibility to permethrin insecticide have also been reported in Zaria, North West Nigeria (Ndams *et al*., 2006).

Conclusion

The result obtained from this study has indicated that all the mosquito vectors in Minna have shown considerable resistance to permethrin which is one of the major insecticides used in the area.

Recommendation

This therefore, calls for urgent intervention in order to forestall the outbreak of mosquito-borne diseases in Minna.

It is also highly recommended that intensity assays be incorporated in order to determine the extent of threat that resistance poses to mosquito vectored diseases control.

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