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Relationship of Climatic Variables with Abundance of Indoor Mosquito Genera in Six Communities in Ekiti State, Nigeria

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Author's contribution

The sole author designed, analysed, interpreted and prepared the manuscript.

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ABSTRACT

Understanding the relationship between climate variables and mosquito abundance is an important factor to determine parasite activity levels and disease risk since various mosquito genera are vectors of parasitic diseases. This necessitated the investigation of relationship between climatic variables and mosquito abundance in Ekiti State, Nigeria with reference to six selected communities. Adult mosquitoes were collected indoor for twelve months in these communities using light traps. The abundance of collected mosquitoes was related with climatic variables (rainfall, relative humidity and temperature). One thousand two hundred and seventeen (1217) adult mosquitoes were collected indoor in all the communities. The population of the mosquito genera was significantly higher (P=0.01) in rainy season than dry season. Average rainfall showed a strong relationship (R^2= 0.751) with *Anopheles* abundance but relationship was weak for both *Culex* (R^2= 0.236) and *Aedes* (R^2= 0.042). The relationship of relative humidity and average temperature with abundance of mosquito genera was generally weak. Since the abundance of mosquito genera was higher in all the communities during rainy season than dry season it will be more appropriate to control mosquitoes in the communities during the rainy season.

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1. INTRODUCTION

Climatic factors affect adult mosquito abundance by altering the quality and quantity of breeding habitats. The relationship between climate variables and mosquito abundance provide important information to determine parasite activity levels and disease risk [1,2]. A number of studies have used environmental temperature (sometimes together with rainfall and/or humidity) to develop maps representing spatial and/or temporal variation in transmission risk of mosquito borne diseases especially malaria infection [3]. This is because various species of mosquitoes act as vectors for parasitic and viral diseases. For instance, *Aedes* contains several species that transmit arboviruses, including yellow fever, dengue, chikungunya, Rift Valley fever and Zika viruses. *Culex* has various species that transmit microfilaria (*Wuchereria bancrofti*) and flavi viruses while various species of *Anopheles* transmit malaria parasites (*Plasmodium*), *W. bancrofti* and arboviruses [4]. This study becomes necessary in Ekiti State of Nigeria as the information regarding climate and mosquito abundance is obviously lacking. Having good understanding of this information will be very useful for the control of mosquitoes in the State.

In order to develop efficient mosquito vector control programs there is need to have information on the seasonal prevalence of the mosquito fauna [5]. A proper understanding of the relationship between rainfall and the abundance of mosquito vectors for instance, has helped to develop a feasible vector control program [5,6]. Rainfall and temperature provide essential mosquito life history traits such as transmission intensity which include mosquito development rate, biting rate and the survival rate [3]. Rainfall and temperature are the proxy variables that have been representing the density level of mosquitoes [7]. Rainfall and temperature affect the development of larvae in the aquatic environment and the survival of adult mosquitoes [8]. This work was initiated with the objectives to investigate the relationship between climatic variables (mainly rainfall, average temperature and relative humidity) and mosquito abundance in Ekiti State, Nigeria with reference to six communities serving as study areas. Ekiti is one of the 36 states in Nigeria and the State has communities that range from peri-urban to rural areas. Therefore, six communities consisted of three peri-urban and three rural areas were selected for this study. The communities were Iye, Ewu, Iyin, Eyio, Agbado and Ilupeju-Ijan. A study involving prevalence of malaria parasite infection had earlier been carried out in these communities [9].

2. MATERIALS AND METHODS

2.1 Selection of Study Communities

The method for selection of the study communities had been fully described in the early study [9]. The six study communities were selected through a multi-stage sampling method in which one peri-urban and one rural area were selected from each of the three Senatorial Districts of Ekiti State. Senatorial District is a geopolitical division that exists in every state of Nigeria. The criteria for categorizing the communities into peri-urban and rural were based on the reports of Ayorinde and Agbodike [10,11]. Table 1 shows the study communities and their coordinates. Ekiti state covers about 6,384 km^2 and had an estimated population of 2,398,957 [12]. The State has a sub-equatorial type climate with one dry season (November - April) and only one rainy season (May - October). The people from these communities were predominantly Yoruba ethnic group and majority of the people engage in farming activities.

Table 1. The six study communities in Ekiti State, Nigeria

Senatorial District	LGA	Community	Coordinates
Ekiti North	Ilejemeje	Iye (Periurban)	N07º57.182' E005º13.881'
		Ewu (Rural)	N07º55.822' E005º10.821'
Ekiti Central	Irepodun	Iyin (Periurban)	N07º39.513' E005º09.365'
		Eyio (Rural)	N07º43.583' E005º10.771'
Ekiti South	Gbonyin	Agbado (Periurban)	N07º35.348' E005º31.261'
		Ilupeju-Ijan (Rural)	N07º34.389' E005º24.303'

2.2 Collection of Mosquitoes in the Study Communities

Adult mosquitoes were collected from the rooms of the volunteers for twelve months in the study communities from July 2017 to June 2018. The households within the area were divided into sections to generate sampling frames for the random selection of houses representative of the area. A house was selected in each section of the divisions. Mosquitoes were collected using miniature Centre for Disease Control (CDC) light traps (Model 512; John W. Hock Company, Gainesville, FL, USA). The miniature CDC light traps were positioned indoors next to a person sleeping under a treated bed net in the randomly selected households in each community. The trap was positioned with the light bulb few centimetres above the floor at the foot end of the person under the bed net. Traps were set for two consecutive days in every month at 7:00 PM and removed at 7:00 AM the following morning [13]. When it was not possible to set the trap in the intended house, it was moved to the nearest similar house. The captured mosquitoes were sorted into sexes and various genera using morphological keys [14].

2.3 Obtaining of Monthly Metrological Data

The monthly meteorological data mainly rainfall, relative humidity and average temperature of the study communities during the time of mosquito collections were obtained from Nigeria Meteorological Agency (NIMET), Abuja, Nigeria.

2.4 Statistical Analysis

Data were analyzed with SPSS version 20 and statistical analyses involved were descriptive, chi-square and regression. A probability value (p-value) of $P < 0.05$ was regarded as significant for chi-square.

3. RESULTS

3.1 Population of Indoors Mosquitoes in the Study Communities

One thousand two hundred and seventeen (1217) adult mosquitoes were collected indoors in all the six study communities for twelve months (Table 2). The female mosquitoes were 98.1% while males were 1.9%. The mosquito genera collected were *Culex* (61.7%), *Anopheles* (35.6 %) and *Aedes* (2.7 %). The population of mosquito genera in the respective communities is shown in Fig. 1. The highest number of *Culex* was collected at Ewu a rural community in Ekiti North, while highest numbers of *Anopheles* and *Aedes* were collected at Ilupeju-Ijan a rural community in Ekiti South. The population of the mosquito genera was significantly higher (P=0.01) in rainy season than dry season (Fig. 2).

3.2 Climatic Variables and the Population of Mosquito Genera in the Study Communities

The average rainfall of the study communities showed a strong relationship (R^2= 0.751) with the total abundance of *Anopheles* mosquitoes collected in the communities (Figs. 3 and 4). A unit increase in the amount of rainfall resulted to 0.263 increase in the number of *Anopheles* mosquitoes. R^2= 0.751, shows that about 75% of the variation in the number of *Anopheles* mosquitoes is predictable from the amount of rainfall while the remaining 25% was due to other factors. However, the relationship of average rainfall with the total abundance of both *Culex* mosquitoes (R^2= 0.236) and *Aedes* mosquitoes (R^2= 0.042) was weak. A unit increase in the amount of rainfall resulted to 0.138 and 0.006 increase in the number of *Culex* and *Aedes* mosquitoes respectively. About 23.6% and 4.2% of the variation in the number of *Culex* and *Aedes* mosquitoes are respectively predictable from the amount of rainfall. The relationship of the total abundance of mosquito genera with average relative humidity is shown in Figs. 5 and 6. The relationship was not strong enough for both *Anopheles* (R^2= 0.379) and *Culex* (R^2= 0.302) and very weak for *Aedes* (R^2= 0.015). About 37.9%, 30.2% and 1.5% of the variation in the number of *Anopheles*, *Culex* and *Aedes* mosquitoes are respectively predictable from the average relative humidity. A unit increase in the average relative humidity resulted to 2.007, 1.68 and 0.039 increase in the number of *Anopheles, Culex* and *Aedes* mosquitoes respectively. Meanwhile, the relationship between the total abundance of the mosquito genera in the communities and the average temperature was generally weak (Figs. 7 and 8). *Anopheles* (R^2= 0.056), *Culex* (R^2= 0.233) and *Aedes* (R^2= 0.007). About 5.6%, 23.3% and 0.7% of the variation in the number of *Anopheles*, *Culex* and *Aedes* mosquitoes are respectively predictable from the average temperature. There was inverse relationship between the average temperature and abundance of *Anopheles* and *Culex* mosquitoes (Fig. 8 a & b).

Table 2. Indoor mosquito genera collected in the study communities

Mosquito genera	Male	Female	Number collected
Culex	18 (2.4%)* (78.3 %)**	733 (97.6 %)* (61.4 %)**	751(61.7 %)**
Anopheles	5 (1.2 %)* (21.7%)**	428(98.8 %)* (35.8%)**	433(35.6 %)**
Aedes	0 (0.0 %)* (0.0 %)**	33 (100 %) (2.8 %)**	33(2.7 %)**
	23 (1.9 %)	1194 (98.1 %)	1217

** = % across the row, ** = % down the column.*

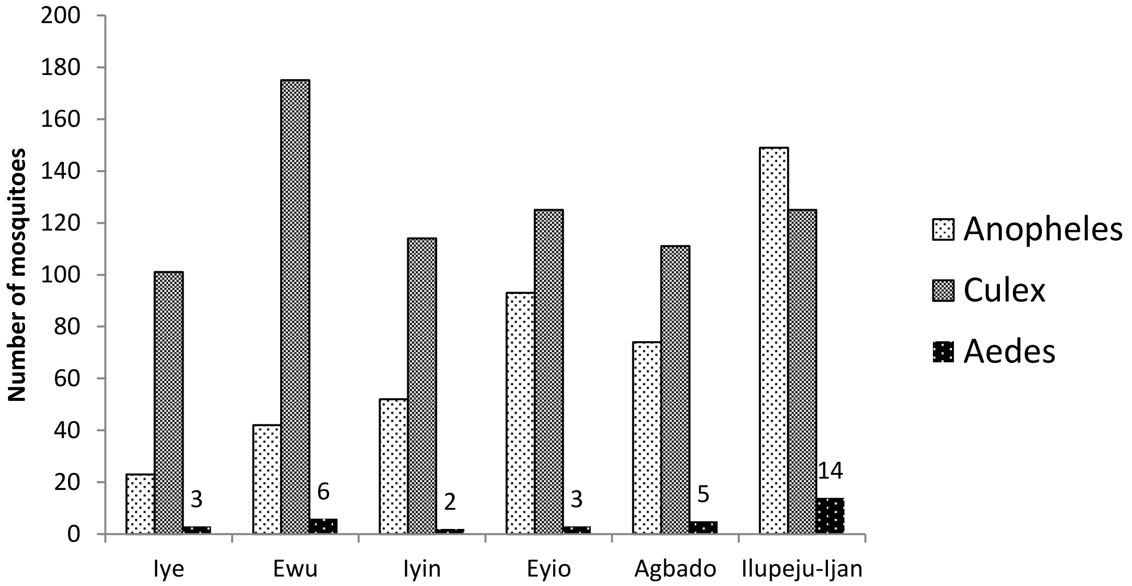


Fig. 1. Population of mosquito genera collected in the study communities

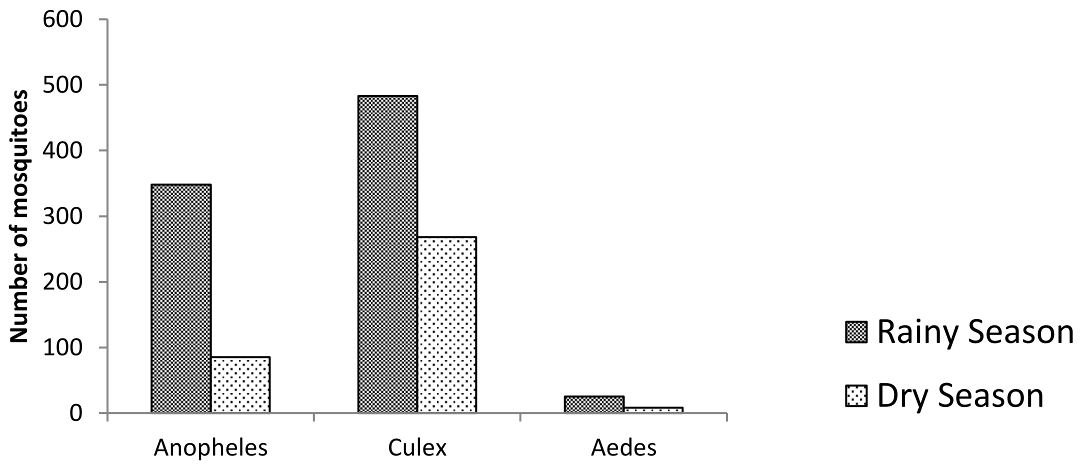


Fig. 2. Population of mosquito genera in rainy season and dry season in the study communities

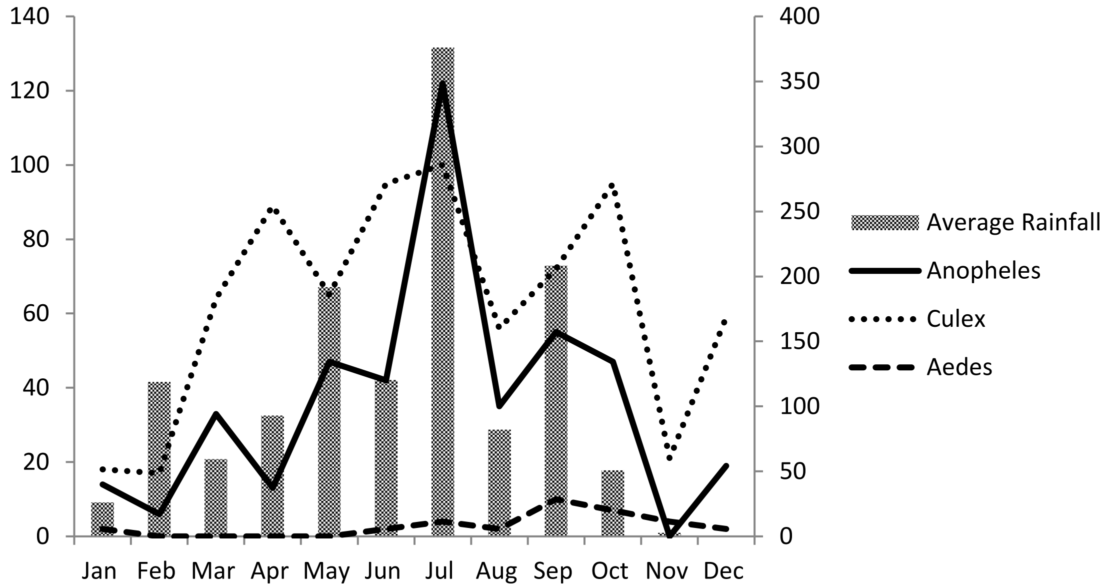
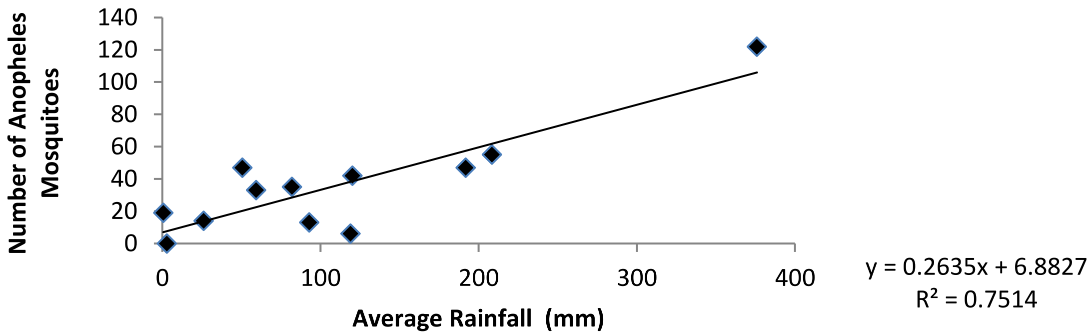
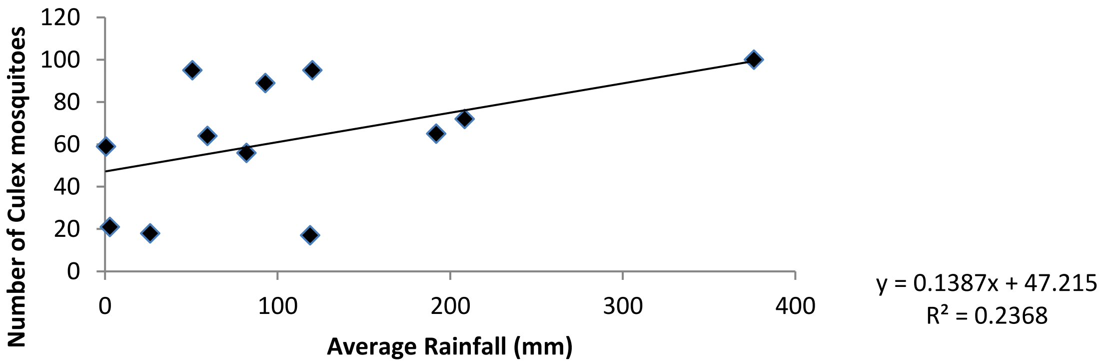


Fig. 3. Chart showing average rainfall and abundance of indoor collected mosquitoes in the study communities

(a)



(b)



(c)

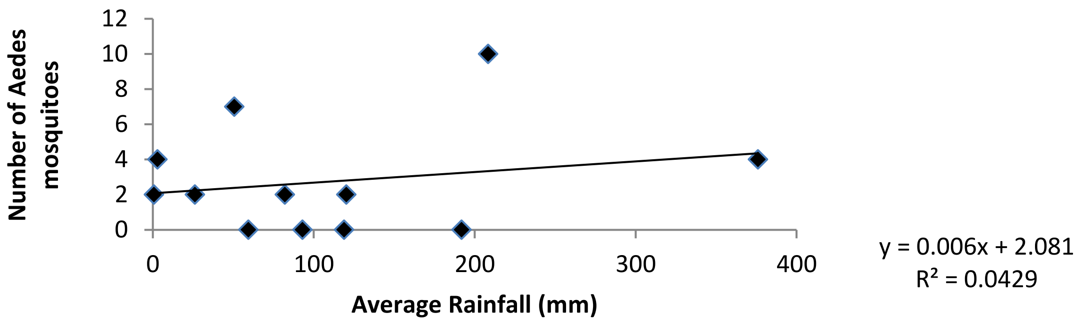


Fig. 4. Relationship between average rainfall and abundance of indoor collected mosquitoes in the study communities in Ekiti State

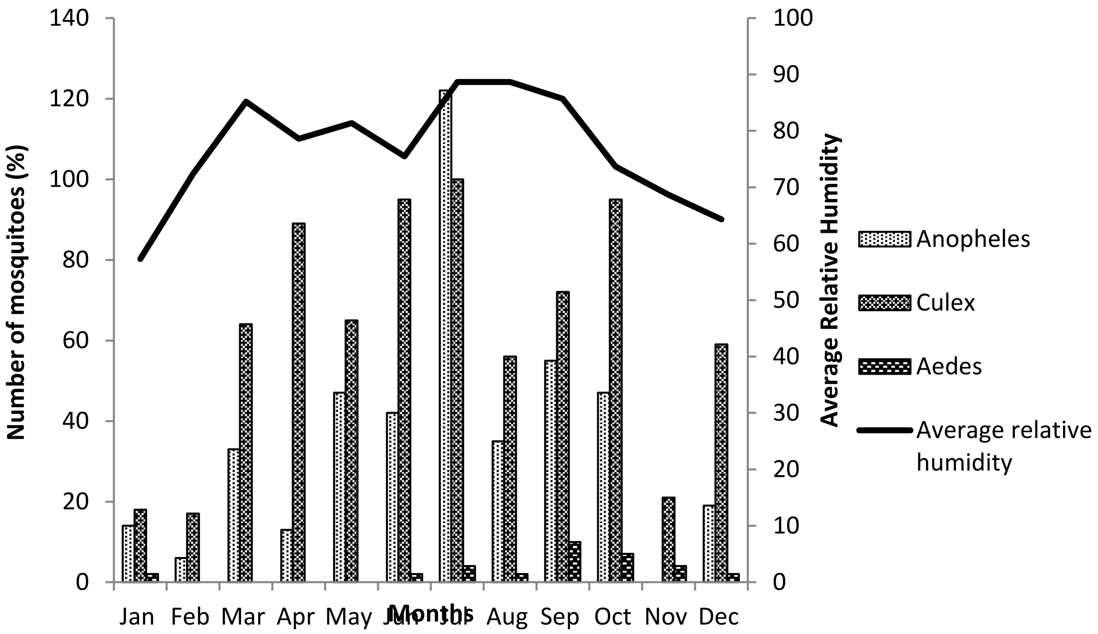
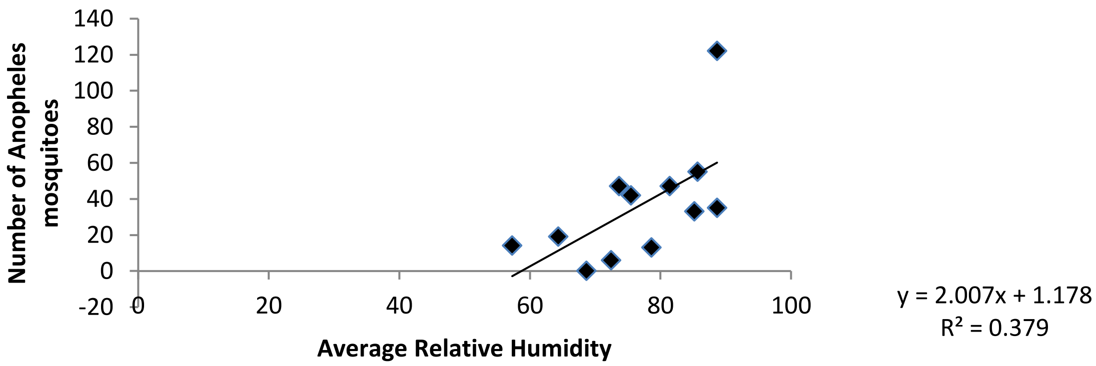
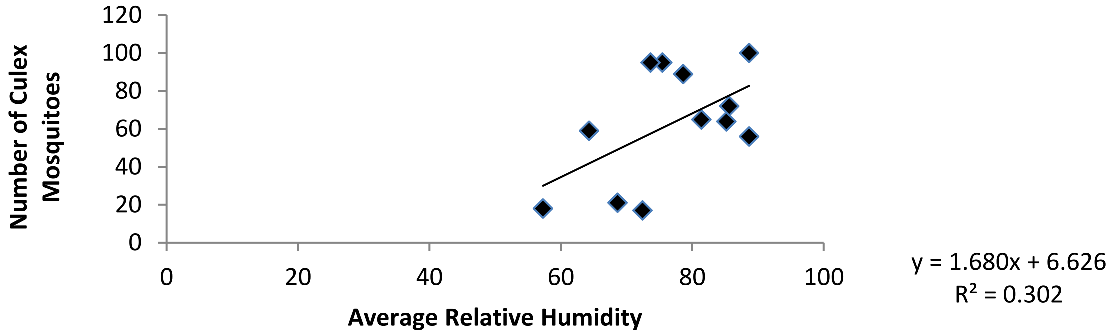


Fig. 5. Chart showing average relative humidity and abundance of indoor collected mosquitoes in the study communities

(a)



(b)



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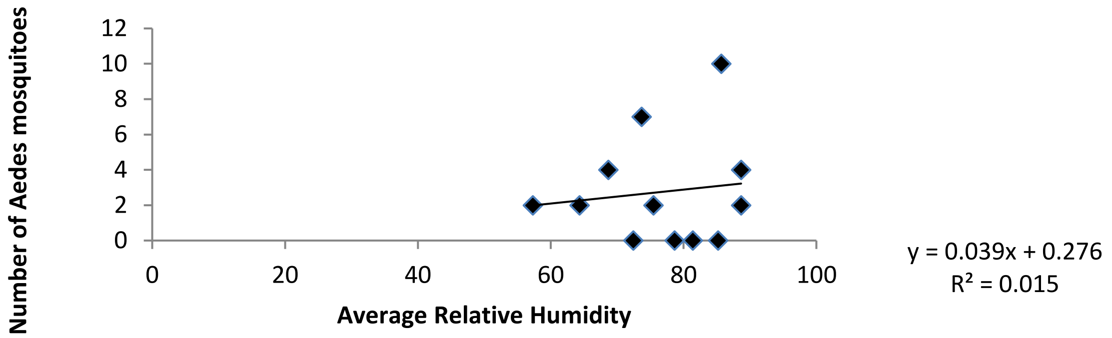


Fig. 6. Relationship between average relative humidity and the abundance of indoor collected mosquitoes in the study communities in Ekiti State

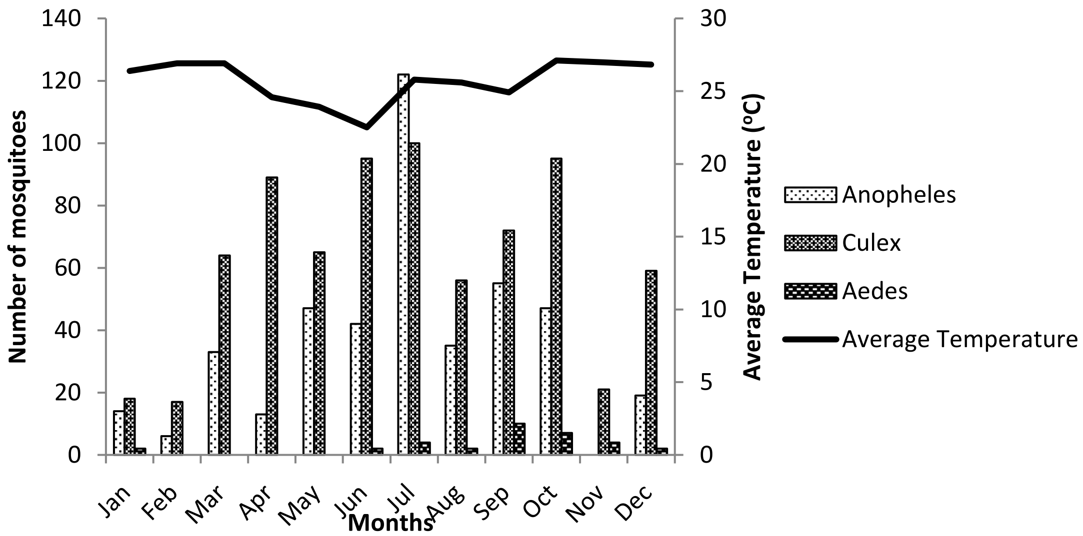
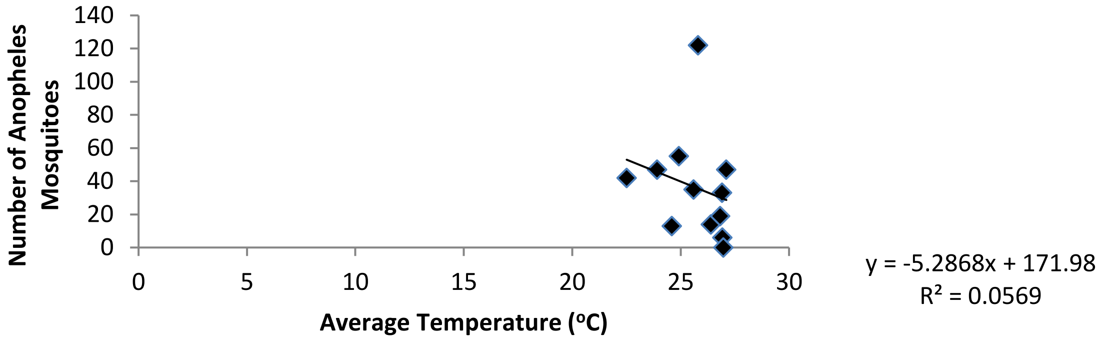
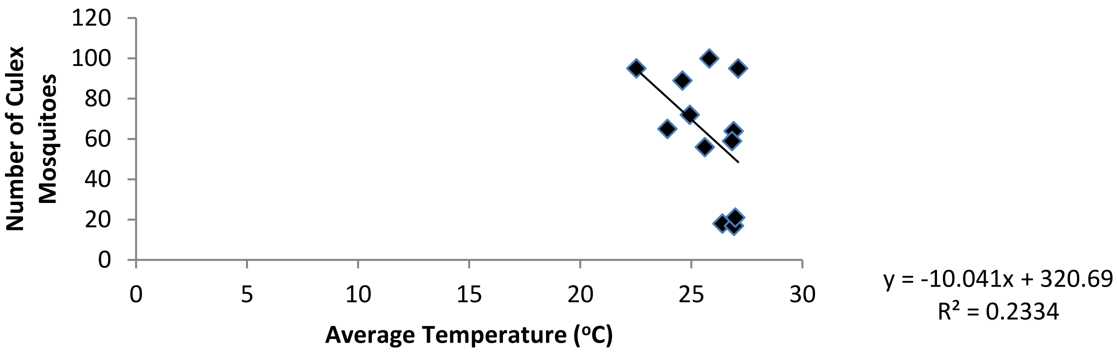


Fig. 7. Chart showing average temperature and abundance of indoor collected mosquitoes in the study communities

(a)



(b)



(c)

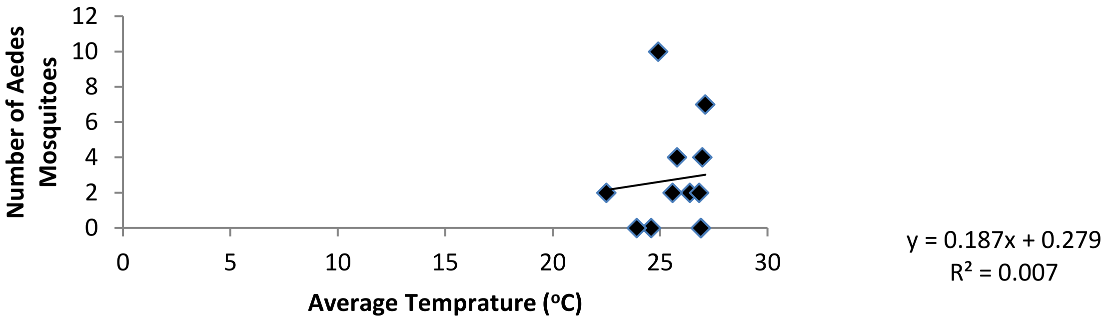


Fig. 8. Relationship between average temperature and the abundance of indoor collected mosquitoes in the study communities in Ekiti State

4. DISCUSSION

The aim of this research was to identify the climatic variables that affect the abundance of mosquito genera in Ekiti State, Nigeria. This will form part of baseline data that could be useful for the seasonal control of mosquito vectors in Ekiti State. Number of mosquitoes sampled was correlated with climatic variables mainly, rainfall, temperature and relative humidity. Rainfall was the major climatic factor that affected the population of *Anopheles* mosquitoes. This could be connected with the breeding of *Anopheles* mosquitoes as they often breed in a natural environment containing clean water created by incessant rains [15]. However, some larvae of *Anopheles gambiae* s.l. have been reported in organically polluted water containing human faeces, oil from refinery and sewage pond indicating that *Anopheles* can as well breed in dirty water [16]. The higher prevalence of malaria parasite infection recorded during rainy season than the dry season in these communities [9] must be due to the population of *Anopheles* mosquitoes (the vectors of malaria parasites) which was higher in the rainy season than the dry season. Temperature appeared not to have a significant relationship with the abundance of mosquito genera in these communities. However, moderate relationship existed between relative humidity and the population of *Anopheles* and *Culex* mosquitoes.

Culex mosquitoes were the most abundant mosquito genera in this study. This could be understood from the biology of the insect. *Culex* breed in all types of water collections including temporary or permanent stagnant water bodies such as drains, septic tanks, wet pit latrines, organically polluted sites and puddles [17], and these breeding sites are found in all these communities throughout the year. Kitching [18] gave some of the breeding sites of various mosquito genera in his study. Various authors have also reported physico-chemical parameters where mosquito larvae can develop and survive in Nigeria [19,20,21]. The higher population of *Culex* than *Anopheles* in this study was contrary to the findings of Amaechi et al. [22] where *Anopheles* mosquitoes were reportedly higher in population density than *Culex*. However, low population of *Aedes* mosquitoes agreed with their findings. The very low population of *Aedes* mosquitoes collected in this study could not have been unconnected with the time of collection which was in the night, whereas, *Aedes* are known to be active and bite during the day time and seldomly seen in the night [23].

5. CONCLUSION AND RECOMMENDATION

Generally, there was a higher abundance of mosquitoes during rainy season than dry season in the study communities, thereby, suggesting that rainfall was favourable to support the continual breeding and survival of mosquitoes in these communities. Therefore, the control of mosquito borne diseases that involved vector control will be more appropriate in these communities and probably in other areas of Ekiti State during the rainy season.

DISCLAIMER

The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

CONSENT

The consents of volunteers whose rooms were used for the collection of mosquitoes were obtained after the aim of the study had been explained to them.

ETHICAL APPROVAL

Ethical approval to conduct this research was obtained from Ethics and Research Committee of Ekiti State University Teaching Hospital, (EKSUTH/A67/07/002) Ado-Ekiti, Ekiti State, Nigeria.

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COMPETING INTERESTS

Author has declared that no competing interests exist.

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