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The Effect of Climatic Factors on the Distribution and Abundance of Mosquito Vectors in Ekiti State

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Abstract
In warm and tropical climatic regions of the world, climatic factors have been associated with relative mosquito abundance and transmission of mosquito borne infections. The main objective of this study is to assess the change in seasonal abundance and distribution of mosquito vectors in relation to climate variables (rainfall, temperature and humidity). Mosquito samples were collected from randomly selected houses in all the Local Government Areas of the State using Aspirators, light trap and pyrethrum spray catch methods from July 2006 to June 2008. Species of Anopheles, Aedes and Culex mosquitoes were collected. Anopheles gambiae s.s had the highest number (43.5%) out the three malaria vectors found. For Aedes and Culex species collected, Aedes aegypti (37.6%) and Culex fatigans (37.1%) have the highest prevalence out of their sibling species. Temperature and Rainfall were highly correlated with the abundance of mosquito vectors. It was observed that relative humidity of at least 50- 55% prolong mosquito survival. The rainy season (March to October) recorded the highest number of mosquito vectors collection with the peak in the months of July and August while the lowest collection was in the month of February when there was little or no rains. The environmental and ecological factors including Human activities enhanced the breeding and abundance of these mosquito vectors.
Keywords: Culex fatigans; Aedes aegypti; Mosquito; rainfall; temperature; abundance

Introduction

Approximately half of the world's population is at the risk of malaria and an estimated 243 million infected cases resulted in nearly 86300 deaths in 2008 (WHO, 2009).In Sub- Saharan Africa (SSA), where 91% of malaria related deaths take place, malaria is estimated to result in an annual loss of 85% of the deaths amongst children below five years of age (WHO, 2010). In addition 40% of all the public Health spending is related to malaria.

Out of all the diseases such as malaria, filariasis, dengue and yellow fever caused by mosquito vectors, malaria is the most important tropical and parasitic disease in the world. Malaria alone accounts for up to 25% of hospital attendance, with young children under five years accounting for about 40% in Africa (WHO, 2002).Filariasis also have been shown to be a public health problem in Africa, particularly in the northern savannah and in the south-western coastal part of Africa (Dunyo et al, 1996).Transmission of yellow fever is under control in many parts of Africa as a result of mass immunization given to children to reduce the incidence.

Studies throughout the world have linked changes in malaria incidence and other related diseases associated with mosquito vectors with pattern of rainfall, temperature and humidity (Briet *et al*, 2008). Rainfall is considered to be a major factor influencing malaria cases in Africa (Abeku, 2007) and a causal relationship between rainfall and malaria transmission is well recognized (Thomson *et al*, 2005). In the highland of Kenya, malaria cases increased by 1.4% to 10.7% per month for each 10millimeter increase in monthly rainfall (with 2-3 months lag) (Hashizume *et al,* 2009).Natural climatic disasters such as floods and cyclones may also have significant relationship with malaria outbreaks.

Temperature, Rainfall and Humidity have been widely associated with the dynamics of malaria vector population and therefore with the spread of the disease. However at the local scale, there is lack of a systematic quantification of these factors on malaria transmission (Githeko *et al*, 2001). Zhou *et al*, (2004) reported that East African Highland have shown that a 1^oC increase in minimum temperature with a lag of time of 1-2 months and 1^oC increase in maximum temperature with a lag time of 2-5 months led to an 80-95% increase in the number of malaria outpatients.

Meteorological factors are important drives of malaria transmission. Ambient Temperature plays a major role in the life cycle of the malaria vector. Temperature between 15^0C - 40^0C and humidity between 55% and 80% are suitable for the completion of the *Plasmodium falciparum* and *Plasmodium vivax* malaria parasites life cycle (Zhou *et al*, 2004). The development of the parasite within the mosquito (sporogonic) cycle is dependent on temperature. The sporogonic cycle takes about 9-10 days at temperature of 280^0C but stops at temperature below 16^0C (Lindsay *et al,* 1996). The daily survival of vector is dependent on temperature as well. At temperature between 16^0C and 36^0C, the daily survival drops rapidly at temperature above 36^0C. The highest proportion of vector surviving incubation period is observed at temperature between 28^0C and 32^0C (Craig *et al*, 1999).The gonotrophic cycle which is the time between blood meals of the vector is short at higher temperatures because digestion speed increases (Haque *et al*, 2010). Therefore higher temperature results in more frequent vector – host contact.

Rainfall provides breeding sites for mosquito to lay their eggs and ensures a suitable relative humidity of at least 50-60% to prolong mosquito survival. Relative humidity below 60% shortens the life span of the mosquito vectors (Rogers *et al*, 2006). The goal of this work is to study the effects of these climatic factors on the distribution and abundance of mosquito vectors in the study area.

Materials and Methods

The study was carried out in Ekiti State, Nigeria from July 2006 to June 2008. Adult mosquito samples were collected between 05.00- 07.00 hours in the morning and 19.00- 21.00 in the evening with aspirators, a light trap and the use of Pyrethrum indoor spray catch methods. The houses used for collection were randomly selected and close to the sites of larvae habitats.

Paper cups covered with netting materials which contain cotton pad soaked in 10% glucose were used for collection. The cups were placed in a cool box and transported to the laboratory where the mosquitoes were anaesthetized with ethyl acetate. They were sorted out and identified by morphological characteristics with the key aids of Strickland *et al*, (1927), Giles *et al*, (1968) and Koekomoer *et al,* (2002). They were later counted and recorded.

The data on minimum and maximum Temperature, Rainfall and relative Humidity for these periods were collected every month from the Ministry of Finance and Budget (Research and Meteorological Dept.) Ado Ekiti, Ekiti State. The water from the sample sites was collected using pH meter to test the pH level.

Results

A total number of 7,468 adult mosquito were collected monthly, out of which 1808 (24.2%) were *Anopheles* species, 2900 (38.8%) for *Culex* species and 2760 (36.9%) for *Aedes* species.

Anopheles gambiae s.s, An. funestus and An.arabiensis were the malaria vectors found during the survey. *An. Gambiae s.s* had the highest prevalence of 787 (43.5%) followed by *An. arabiensis* 616 (34.1%) and the least in number was *An. funestus* 405 (22.4%) (Table 1).

Table 1: Monthly mosquito species abundance in Ekiti State, Nigeria

	Monthly abundance of mosquito												
Mosquito species	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aus**	**Sep**	**Oct**	**Nov**	**Dec**	**Total**
Anopheles	21	21	32	68	80	99	118	131	80	64	41	32	787
gambiae	30	28	38	35	74	84	82	84	64	30	39	28	616
An. arabiensis	17	14	18	15	56	67	60	70	36	15	19	18	405
An. funestus	68	63	88	118	210	250	260	285	180	109	99	78	1808
Total	58	54	55	87	83	100	140	142	95	98	96	84	1091
Aedes aegypti	35	40	41	70	64	80	101	98	70	75	77	64	816
Ae. albopitus	38	32	41	58	58	68	80	81	47	58	46	48	655
Ae. vittatus	18	28	22	37	46	57	20	20	28	24	24	14	338
Ae. qalpalis	49	154	159	261	251	305	341	341	240	255	243	210	2900
Total	55	50	50	87	79	108	128	128	98	90	90	69	1025
Culex fatigans	36	29	47	64	66	71	110	110	75	70	71	50	792
Cx. (P) pipiens	29	21	30	48	58	61	87	87	46	53	51	42	605
Cx.	20	16	24	17	44	51	33	33	24	22	28	29	338
quinquefascia	140	116	151	247	247	291	358	358	243	235	240	190	2760
Cx. tigripes													
Total													
Total	357	333	408	586	708	846	932	976	663	599	582	478	7468

The month of August recorded the highest number of the mosquito species with *Aedes aegypti* and *Culex fatigans* found to be most common of all the species. The distribution and abundance of the mosquito with weather data are shown in Figures 1, 2 and 3

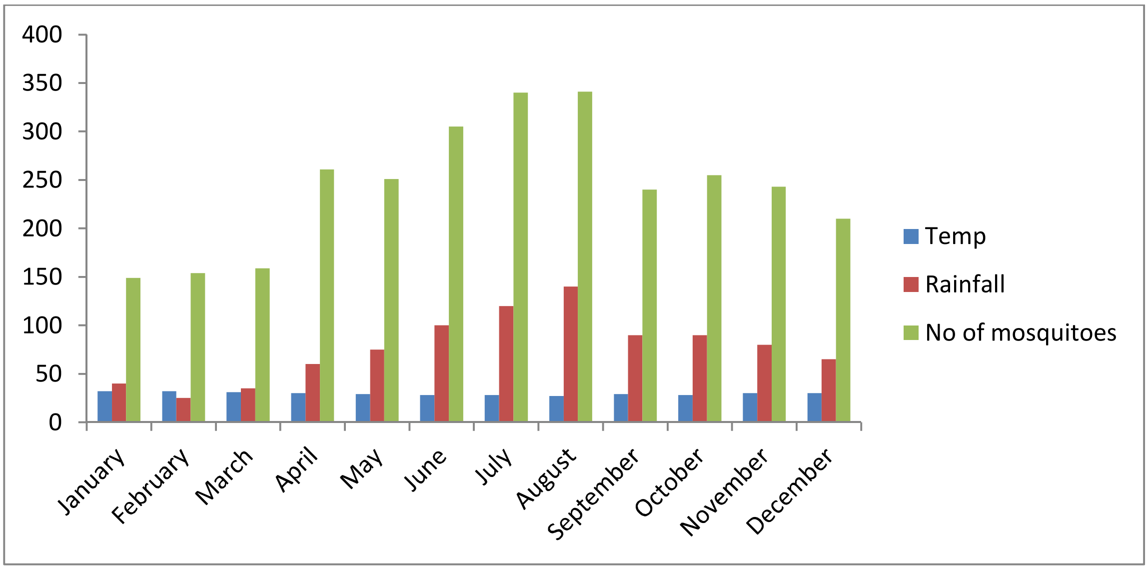

Fig. 1: Seasonal prevalence of *Anopheles* species with temperature and rainfall in Ekiti State.

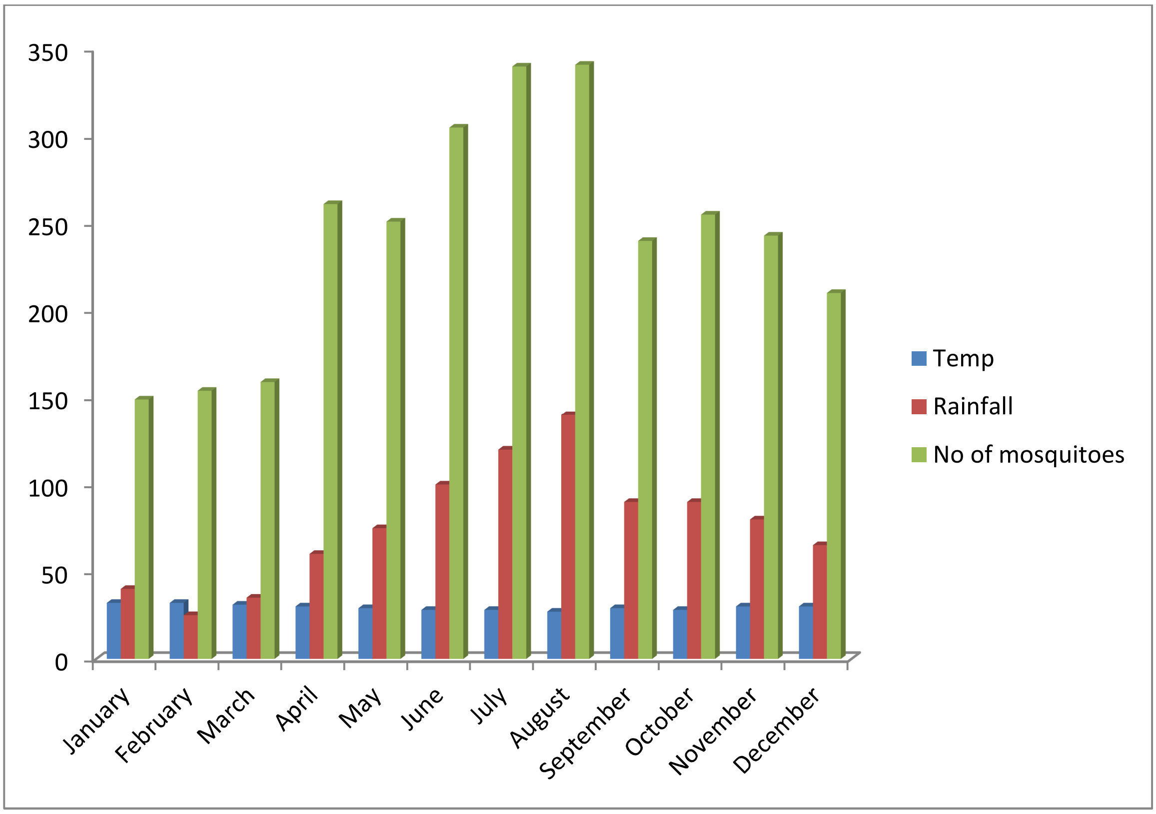

Fig. 2: Seasonal prevalence of *Aedes* species with temperature and rainfall in Ekiti State.

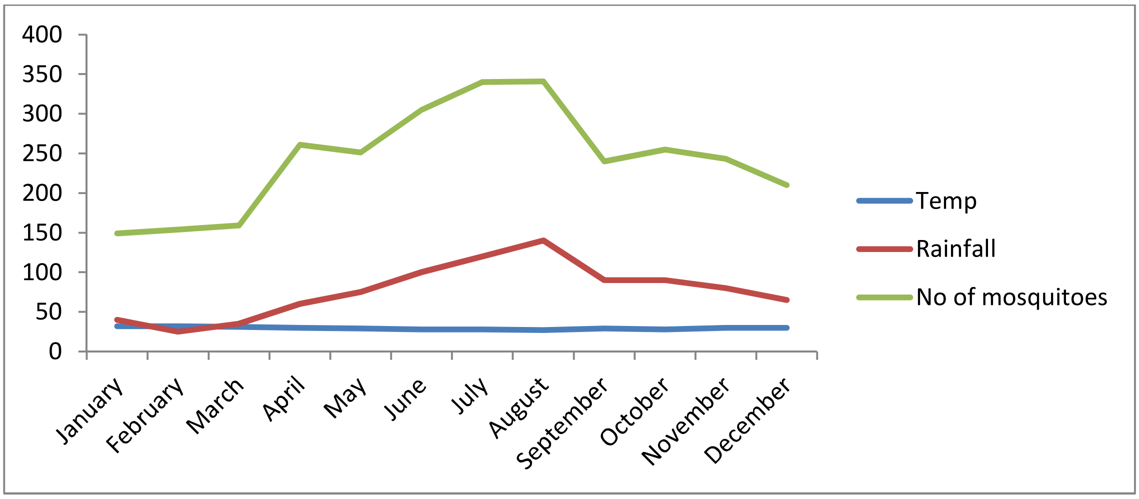

Fig. 3: Seasonal prevalence of *Culex* species with temperature and rainfall in Ekiti State.

Correlation coefficient of the average temperature and the total number of monthly mosquito collection result showed that the average temperature exhibit high correlation with the total number of mosquito collected ($p<0.05$) which means that temperature has a significant effect on the abundance of mosquito vectors (Table 2). The correlation analysis between monthly rainfall and the total number of mosquito collected revealed that there was a very high correlation. Rainfall had a significant effect on the distribution and abundance of the mosquito vectors ($p<0.05$) (Table 2).

The result of the T-test analysis carried out on the effects of both temperature and rainfall on the monthly abundance of mosquito vectors showed that they have a significant effect (Tab. 2).

Table 2: Analysis of correlation between the meteorological parameter and abundance of mosquito vectors (n=12).

Variables	CC	P-value
Rainfall vs TNMVs	0.85	0.001
Temperature vs TNMVs	5.02	2.20
Rainfall & Temperature Vs TNMVs	4.77	2.080

CC- Correlation coefficient; TNMVs- Total Number of Mosquito Vectors; $p< 0.05$

Discussion

It is important to study the impact of weather on the transmission of malaria and other diseases associated with mosquito vectors, as global warming might change the pattern of temperature and rainfall which may directly or indirectly influence mosquito density or distribution (Wu *et al*, 2007).

In this present study, the temperature was between 26°C and 32°C with average humidity of 55% which might have facilitated the higher mosquito abundance. Similar kind of results has also been previously reported on the maximum survival rate of mosquito for the related temperature and humidity (Murty *et al*, 2010). Thu *et al*, (1998), also submitted in his report that humidity is one of the vital factors affecting the life cycle pattern of mosquitoes and it has been observed that the temperature at 28°C with 55 – 55% relative humidity is the most appropriate condition for the elevation in mosquito density or abundance than the condition of lower temperature with higher humidity (22°C/80 – 85% RH). Three main species of mosquito vectors found were *Anopheles, Culex* and *Aedes*. Among the three malaria vectors found, *An. gambiae s.s* had the highest number during the rainy periods (May - August) while *An. funestus* dominated the dry season collection which may be as a result of their feeding habit and resting behaviour. For *Aedes* mosquitoes, four species were found out of which *Ae. aegypti* which is the vector of Dengue and Yellow fever had the highest number of abundance while Ae. palpalis had the least number. *Cx. fatigans* had the highest number and *Cx. tigripes* had the least abundance . This result may be as a result of the fact that their larvae can colonize and survive in almost all habitats such as barrels, drainages, tyres, pots, discarded plastics and bottles, and tanks.

The pattern of rainfall also affects larval habitat and vectors population size. In some cases, increased rainfall may increase larval habitats and vector population by creating a new habitat. Excessive rain could also eliminate habitats through flooding, thus decreasing the vector population especially malaria vectors because they prefer sunlit pools of water. During the dry season, limited rainfall can also create new habitats when water in the rivers is drawn into pools, providing the perfect breeding site for a number of mosquito species, thus favouring disease transmission as also observed by Gubler et al, 2001.

The temporal change in mosquito abundance is mainly caused by rainfall. *An. gambiae* adults were more abundant during the rainy season than during the dry season which is consistent with the finding that the number of larval habitats was substantially higher in the rainy season than in the dry season as previously reported by Zhou *et al*, 2007. The lower abundance of *An. funestus* adults than *An. gambiae* was caused by the lack of suitable, long-lasting larval habitats for An. funestus because its larvae normally take three weeks to develop into adults, and *An. gambiae s.s* larvae require approximately 10 days in sun-lit habitats.

However, it was revealed that tree canopy coverage exhibited a significant effect on the mosquito abundance in houses because it reduces the water temperature of larval habitats surrounding the houses because canopy cover reduces the amount of solar radiation reaching the larval habitats. It was also observed that the air temperature inside a house is affected by tree canopy.

Apart from the importance of congenial environmental and ecological factors such as breeding sites, humidity, temperature and rainfall, human activities such as agricultural practices, lumbering etc also contribute to the distribution and abundance of these mosquito vectors especially the availability of host for blood meal.

In conclusion, there was a high correlation of Temperature and rainfall on the distribution and abundance of malaria and other related diseases associated with mosquito vectors. A small temperature rise either through seasonal variability, local microclimatic changes due to modification in vegetation cover or to global warming can increase disease transmission. The meteorological parameters are good prediction of malaria and associated disease risk.

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