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Abundance of Mosquitoes larvae in various microhabitats and the concern for invasion of human community

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Abstract
A survey was conducted in five microhabitats of Jos North Local Government Area of Plateau State to determine the prevalence and abundance of mosquito larvae in ponds/streams closed to residential areas. The research goal was to describe the pattern of composition of mosquitoes dominated invertebrate communities and to test the abundance of different species of mosquitoes as a measure of identifying which area could be more prone to malaria disease infection if not well managed. The work composed of two questions about community composition and the species of invertebrates at sites: (1). How do the presence of a pond or stream/river near a community support the presence of larvae which is critical for understanding processes affecting adult population; (2). To ascertain if any differences in habitat gradients with populations and community composition of mosquitoes may be important for understanding disease transmission in different kinds of microhabitats which may aid in planning more effective vector control strategies. A breakdown from the collections conducted in the five microhabitats indicated that, of the 3, 110 larval stages collected over three different dates, more number of *Anopheles* species were recorded in the Tudun wada microhabitat than in other microhabitats. Coincidentally, it was also the area where an unidentified species of larvae were recorded. Fewer numbers of *Aedes* were collected as compared to the others. In consideration of the instars stages that were measured, it was recorded that more early instars were collected as compared to the late instars. This indicates oviposition is at a climax as compared to the survival of the larval stages. In conclusion, it could be inferred that there is a great invasion of mosquitoes in the human community which calls for a serious concern for governmental and non-governmental organizations to increase more funding to curtail health hazards that could come from mosquito bites.

Keywords: Mosquitoes, ponds/streams, microhabitats, gradients, cues, Jos-Nigeria

1. Introduction

Mosquitoes are members of the family *Culicidae* containing three sub-families namely: *Anophelinae*, *Toxorhynchitinae* and *Culicinae* (Delvin 2010) [1]. They have a world-wide distribution occurring in tropical, sub-tropical and temperate regions and inhabit both aquatic and terrestrial habitats (Dorothy 2010) [2]. They have been incriminated in the sole transmission of important human diseases including malaria, filariasis, yellow-fever, dengue fever etc (Belding 1942; El-Badry and Al-Ali 2010; Balakrishnan *et al*., 2011; Chakkaravarthy *et al*., 2011; Paulraj *et al*., 2011) [3, 4, 5, 6, 7]. These diseases have had serious negative impacts on the economic development as well as medical and social well-being of people living in their areas of prevalence (Amiruddin *et al*., 2012) [8]. The vectorial capacity of mosquitoes for the diseases they transmit is largely influenced by the intensity of larval production from breeding habitats (Depinay *et al*., 2004) [9]. These preferred breeding sites of the different mosquitoes and other environmental factors also affects their distribution and prevalence of diseases they transmit (de Souza *et al*., 2010). In essence, the study of the distribution and prevalence of mosquito larva in various breeding habitats should be carried out to create awareness of the possible diseases that are likely to affect a particular locality.

Costanzo *et al*. (2005) have noted that one of the habitat mosquitoes used as breeding sites are tires found in peri-domestic areas which has greatly attracted attention, as their locations close to homes have been reported to have significant effect on human health.

In essence, illegal dumping of tires in urban and wooded areas, coupled with declines in natural mosquito breeding sites has made discarded tires an important source of disease vectors. Additionally, Ponds and streams located along settlements especially in developing countries have also been observed to serve as breeding spots for mosquitoes.

Mosquitoes are estimated to transmit diseases to more than 700 million people annually in Africa, South America, Central America, Russia and much of Asia with millions resulting to deaths (W.H.O. 2010; CDC 2010) [11]. In 2004, mortality due to malaria peaked at 1.82 million, but fell with the availability of more sensitive diagnostic tools, effective use of anti-malarial drugs, improved personal protection and mosquito control to 1.24 million in 2010 (714, 000 children < 5 years and 524,000 individuals $\geq$ 5 years), although over 80 % of the malaria mortality occur in Sub-Saharan Africa (Murray *et al*., 2010; W.H.O., 2011) [12, 13]. Nigeria is known for high prevalence of malaria and the disease remains one of the leading causes of childhood and maternal morbidity, low productivity and reduced school attendance (Aribodor *et al*., 2007) [14].

Of the various diseases caused by mosquitoes, it is estimated that dengue fever puts two-fifths of the world's population at risk of infection, while malaria accounts for 10 % of Africa's overall disease burden (Okenu 1999; W.H.O. 2003; Njan-Nloga *et al*., 2007) [15, 16, 17]. Filariasis has also been shown to be a public health problem in Africa, particularly in the Northern savannah and in the South-western coastal parts of Africa (Dunyo *et al*., 1996) [18].

Usually, mating of adult mosquitoes occurs in flights and Copulation differs in various species. A single male can mate with several females without necessarily inseminating them all (Gillet 1972) [19]. The adult mosquito survives one week (in the natural habitat) and one month in captivity (Malar 1992).

The subfamily *Anophelinae* comprising of three genera is been reported to lay three eggs singly on water surface, the legs are boat shaped and have air filled floats which prevent them from sinking although few species such as *Anopheles cinercus* and *Anopheles phimbeus* do not have floats and hang perpendicular in the water. *Chagasia* on the other hand have multiple floats and their eggs generally cannot withstand desiccation (Delvin 2010) [1].

Among the *Culicinae* which is the largest subfamily comprising of 2925 species in 23 genera, it is difficult to describe their morphologically distinguishing features and biology (Lane and Crosskey 1993). For instance, the *Culcine* eggs vary greatly in shape and method of oviposition; but none possess air-filled floats. In some genera, the eggs are oval and black, laid singly and able to withstand desiccation (*Aedes* and *Psorophora*). In contrast, the eggs of *Culex*, *Coquillettidia* and *Culiseta* are longer and thinner, brownish forming rafts and cannot withstand desiccation. In *Mansonia*, the eggs are stuck together in a jelly like mass on the under surface of floating aquatic vegetation. Overall, the *Culicine* larvae occur in a wide variety of places with high nutrient values and low oxygen levels, including clean water for *Aedes* species which breed efficiently in both rainy and dry season (Opoku *et al*., 2005). *Mansonia* species on the other hand breed mainly in permanent collections of water that has floating vegetation. The *Culicine* larvae are noted to possess a siphon with usually more than ten setae in the mouth brushes and almost always a comb on the last abdominal segment. They readily suspend on water surfaces with the use of their siphons hanging down at angle or as *Anophelines* in the case of short siphons. The *Mansonia* larvae insert their siphons into water plants.

The subfamily *Toxorhynchitinae* has only one genus-*Toxorhynchites* which is not harmful to man, but coincidentally is the biggest in size among the subfamilies and do not feed on blood (Delvin, 2010) [1] but on plants only and have been used as biological control agents of mosquitoes (Bates 1949) as they are considered the most primitive in the family. Their larval habitats, obligatory feeding habits and morphological characteristics have been described by (Lane and Crosskey 1993).

Adult vector densities of mosquito larvae are very low in the dry season but increase sharply at the onset of the rainy season (Sogoba *et al*., 2007) [22]. This can be attributed to the availability of breeding sites for mosquito and from where the environment is seeded with mosquito larval.

Disturb with the various kinds of mosquitoes related-illnesses recorded in hospitals and dispensaries in Jos, a cross-sectional study was designed with the aim of identifying the various mosquitoes larvae, their prevalence and distribution in various micro habitats within Jos North L.G.A. of Plateau State, North Central Nigeria. The specific objectives were to identify the collected mosquito larvae within the various micro habitats; to ascertain the prevalence and the distribution of larvae in various micro habitats; to ascertain if environmental factors associated with ponds/rivers are important for accurate predictions of mosquitoes at the generic levels. Specifically, (1). How do the presences of a pond or stream/river near a community support the presence of larvae which is critical for understanding processes affecting adult population; (2). What, if any, differences in habitat gradients with populations and community composition of mosquitoes may be important for understanding disease transmission in different kinds of microhabitats and may aid in planning more effective vector control strategies.

2.0 Materials and Methods

2.1 Study Area

The study was conducted in Jos North Local Government Area of Plateau State, Nigeria. Jos North is a Local Government Area in Plateau State, Nigeria. Its headquarters is in the center of the city of Jos. It has an area of 291 km^2 and a population of 429,300 at the 2006 census (www.wikipedia.com). Plateau State is located in the Northern Guinea Savanna vegetation belt. It is one of the two found in Nigeria with a geographical landscape that predominates with Plateau with most found within Jos. The Plateau high land stands at an average height of 400 m above sea level, covering 8600 km^2 with an average altitude of 1280 metres having its highest peck rising above 1529 m of the famous Shere hills in the area of the Citizenship Mountain School, Jos. The geographical coordinates lies between latitude 9 55^{0}7 N and longitude 8 53 54 E. The climate is semi-temperate with temperatures ranging from 18 ºC (64.4 ºF) to 25 ºC (77.0 ºF). The city of Jos receives about 1400 mm (55.1 in) of rainfall annually. The state provides a hydro geographical head for many rivers in the Northern areas, several of which are fast flowing. During the dry season, the hydro geographical head for many rivers leave smaller patches of water which are stagnant and conducive for breeding mosquitoes.

2.1.1 Study Location and sample collection
Five different areas within Jos North LGA characterized with different habitat gradients (ponds, streams and rivers) and located five to ten kilometers apart were selected for the study. The areas comprised of Angwan Rukuba, Farin Gada, Rukuba Road, Tudun Wada and Angwan Rogo. Samples were collected three times between the months of March and April, 2015 at the onset of the rainy season, when it was certain that larvae collected would be from the current season rather than larvae hatching from eggs laid the previous season.

2.2.1 Collection Technique
The method of collection used for the ponds was the partial submersion technique. This method involved pushing the dipper (small bowl), tilted at about 40 degrees, straight down adjacent to the vegetation to flow into the dipper (small bowl), carrying the larvae with the flow (Claudia 1995; 2008). At the sites of collection, the temperature of the water was taken. The dip using the dipper (small bowl) placed on water and then lifted up and transferred into a white plastic bowl to check for the presence of mosquito larvae. Any water with larvae was poured into the bucket with lid containing water ready for transportation to the laboratory. In all, five litres of water were collected at each site.

2.3 laboratory identification of mosquito larvae
In the laboratory, the mosquito larvae were sorted out into different Genera mainly *Anopheline* and *Culicine* and put into small bowls labeled according to Genera and locations with the aid of a dropping pipette. The *Anopheline* and *Culicine* mosquito larvae were identified through their position in water. While the *Anopheline* mosquito larvae lie parallel in water, the *Culicine* mosquito larvae were observed to lie diagonally in water. The different larvae were identified using the key provided by Gillet (1972) [19]; Gordon and Laviopierre (1978) [24]. In addition,

***Anopheles gambiae* sl were observed from other features such as:** their **Palps** which were smooth and as long as the proboscis and some cases smooth and dark except for pale tip; their **Thorax** were Nearly black with scale and in some instances Tuft of white scales at front end, otherwise scales; their **Scutellum** had No lobe; their **Wings** were Spotted with pale or dark patches on costa and in some instances mainly dark-scaled with pale interruption of costa few and short (Pale areas more extensive in some Congo species); their **Legs** had Irregular specked (only just visible), whereas in others, they were dark except for pale spots at tips of tibiae and occasionally at tips of femora as well; and their **Abdomen** were Dark and hairy whereas in others No Scales.

For the ***Aedes aegypti*,** their **Proboscis** was Dark; their **Palps** were short and dark; their **Thorax** was Silver-white on dark background; **Scutellum** was Trilobed; their **Wings** were dark-scaled without conspicuous spots; their **Legs** were with white and black bands; and their **Abdomen** was pointed, black with white bands.

For the ***Culex pipiens fatigans*,** their **Proboscis** was dark and long; while **Thorax** was nearly black with scale and in some instances pale brown; their **Palps** were dark and short; their **Wings** were Narrow dark scaled; **Abdomen** was **d**istinctly blunt at tips; with white bands along the base of each tergit; whereas the **Scutellum** were Trilobed.

The larvae (early and late instars) were then counted; lengths measured with the aid of a miniscule placed under the eyepiece of microscope and transferred into an Eppendorf tube containing 70 % ethanol.

2.4 Data Analysis
Data analysis was analyzed using the Multivariate analysis of variance (MANOVA, PROC GLM, SAS Institute Inc., 2004) for difference in temperature at different site and the Principal Component Analysis (PCA-PROC FACTOR SAS Institute Inc., 2004) to summarize invertebrate community structure in ponds/streams across all sampling dates for all sites.

Results
3.1: Habitat and species of mosquitoes over 5 different sites
In all the five different sites (micro habitats) sampled for mosquito larvae, the results indicated that three thousand, one hundred and ten larvae were collected (Table 1.). A breakdown showed that 894 (27.9 %) were *Culex* species, 1458 (45.5 %) were *Anopheles* species, 752 (23.5 %) were *Aedes* species whereas six unidentified larval species were also identified. A figurative representation is as shown in Figure 1. A univariate statistical analysis was conducted on obtained results and a significant difference was observed between the species and the areas (Table 2). No significant difference was obtained within the species and the various areas, which necessitated a Posthoc test be conducted (Table 3 and Table 4). The estimated marginal means of the species of mosquitoes collected in the various areas is as shown in Figure 2.

Table 1: Habitat and species of mosquitoes over five different sites (n=5 liters/site) Area (Habitat)

	Species of mosquitoes				
	Anopheles	Culex	Aedes	Others	Total
Angwan Rukuba	250	189	226	-	655
Rukuba Road	185	201	114	-	500
Farin Gada	30	72	60	-	162
Angwan Rogo	489	114	122	-	725
Tudun Wada	504	318	240	6	1068
Total	1428	891	866	6	3110

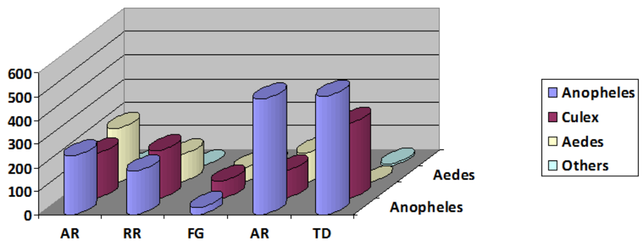

Fig 1: Abundance of larval species in the various microhabitats

Table 2: Univariate Analysis of Variance Tests of Between-Subjects Effects

Dependent Variable:values					
Source	**Type III Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**
Corrected Model	141444.317[a]	19	7444.438	4.900	.000
Intercept	169708.017	1	169708.017	111.697	.000
Areas	38017.733	4	9504.433	6.256	.001
Species	69162.450	3	23054.150	15.174	.000
Areas * Species	34264.133	12	2855.344	1.879	.067
Error	60774.667	40	1519.367		
Total	371927.000	60			
Corrected Total	202218.983	59			
a. R Squared = .699 (Adjusted R Squared = .557)					

Table 3: Post Hoc Tests (Areas) Homogeneous Subsets values Duncan[a, b]

Areas	**N**	**Subset**		
		1	**2**	**3**
Farin Gada	12	13.5000		
Rukuba Road	12	41.6667	41.6667	
Angwan Rukuba	12		55.4167	55.4167
Angwan Rogo	12		66.3333	66.3333
Tudun Wada	12			89.0000
Sig.		.084	.151	.052

Means for groups in homogeneous subsets are displayed.
Based on observed means. The error term is Mean Square (Error) = 1519.367.
a. Uses Harmonic Mean Sample Size = 12.000.
b. Alpha = .05.

Table 4: Species Homogeneous Subsets values Duncan[a, b]

Species	**N**	**Subset**		
		1	**2**	**3**
others	15	.4000		
Aedes	15		57.7333	
Culex	15		59.4000	
Anopheles	15			95.2000
Sig.		1.000	.907	1.000

Means for groups in homogeneous subsets are displayed.
Based on observed means. The error term is Mean Square (Error) = 1519.367.
a. Uses Harmonic Mean Sample Size = 15.000.
b. Alpha = .05.

Profile Plots

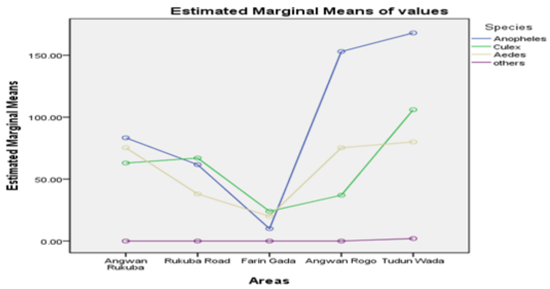

Fig 2: Estimated marginal means of the species of mosquitoes in the various areas

3.2: Early and late instars stages from microhabitats

Measurements of the larvae stages were carried out as shown in Table 5 with more early instars stages collected more than the late stages except for the Farin gada area. A univariate statistical analysis carried on the obtained results indicated that although a significant difference was obtained between the areas and instars stages, and within the instars stages, no significant difference was obtained with regards to the various areas (Table 6). A Posthoc test was then conducted for the areas to obtain a significant difference (Table 7). An estimated marginal means between the instars stages and the various areas was then plotted (Figure 3).

Table 5: Early and Late instars collected at various sites with dates

		INSTARS		
Area	**Date**	**EI**	**LIs**	**Total**
AR	30/3/2015	124	156	280
	2/4/2015	158	101	259
	22/4/2015	97	39	136
Total		379	296	675
RR	30/3/2015	96	89	185
	2/4/2015	83	144	227
	22/4/2015	49	39	88
Total		223	267	500
FG	30/3/2015	15	39	54
	2/4/2015	20	55	75
	22/4/2015	17	16	33
Total		52	110	162
ARo	30/3/2015	218	189	407
	2/4/2015	166	121	287
	22/4/2015	60	42	102
Total		444	352	796
TW	30/3/2015	361	123	484
	2/4/2015	58	247	305
	22/4/2015	192	81	273
Total		611	457	1068

Table 6: Univariate Analysis of Variance Tests of Between-Subjects Effects Dependent Variable:values

Source	**Type III Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**
Corrected Model	82996.167[a]	9	9221.796	1.826	.126
Intercept	340267.500	1	340267.500	67.381	.000
Area	75287.333	4	18821.833	3.727	.020
Instars	1809.633	1	1809.633	.358	.556
Area * Instars	5899.200	4	1474.800	.292	.880
Error	100997.333	20	5049.867		
Total	524261.000	30			
Corrected Total	183993.500	29			

a. R Squared = .451 (Adjusted R Squared = .204)

Table 7: Post Hoc Tests (Area) Homogeneous Subsets values Duncan[a,b]

Area	**N**	**Subset**		
		1	**2**	**3**
Farin Gada	6	27.0000		
Rukuba Road	6	83.3333	83.3333	
Angwan Rukuba	6	112.5000	112.5000	112.5000
Angwan Rogo	6		132.6667	132.6667
Tudun Wada	6			177.0000
Sig.		.061	.269	.152

Means for groups in homogeneous subsets are displayed.

Based on observed means. The error term is Mean Square(Error) = 5049.867.
a. Uses Harmonic Mean Sample Size = 6.000.
b. Alpha = .05.

Profile Plots

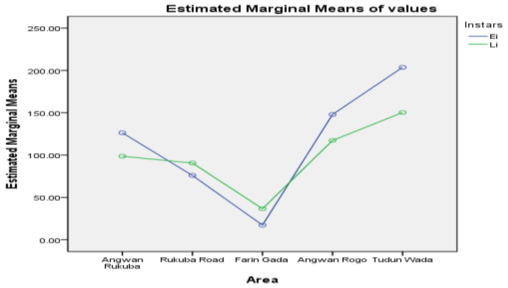

Fig 3: Estimated marginal means between the instars stages and the various areas

3.3: Mean and Standard deviations of Early and late instars stages from microhabitats

Measurements of the larvae stages was carried out and the mean and standard deviations were also calculated (Table 8). Statistical analysis carried out with MANOVA on the early and late instars stages and locations showed that based on observed means, the error mean term square is 4.44 and 0.05 level of significance was observed (Table 9)

Table 8: Early and late instar stages collected at various microhabitats

Species	EI (mean +SD)	LI(mean +SD)	TOTAL
AR			
An	150(1.60+1.13)	120(3.53+1.73)	270(5.13+2.85)
Cx	89(1.73+0.87)	100(2.66+2.63)	189(4.39+3.50)
Ae	140(2.32+0.58)	76(3.43+2.33)	216(5.76+2.91)
Others	0	0	0
Total	379(5.65+2.56)	296(9.62+6.69)	675(15.27+9.26)
RR			
An	93(1.80+0.64)	97(3.60+2.19)	80(5.41+2.83)
Cx	54(0.95+1.22)	65(5.18+0.77)	119(6.13+1.99)
Ae	81(2.09+0.75)	120(3.91+2.21)	01(5.80+2.96)
Others	0	0	0
Total	228(4.847+2.61)	282(12.29+5.16)	500(17.34+7.78)
FG			
An	17(0.60+0.82)	13(3.64+1.91)	30(4.24+2.73)
Cx	16(1.16+1.27)	56(4.38+1.52)	72(5.54+2.79)
Ae	19(0.88+1.20)	41(4.79+0.68)	60(5.67+1.87)
Others	0	0	0
Total	52(2.64+3.28)	110(12.81+4.11)	162(15.45+7.39)
ARo			
An	256(1.79+0.70)	223(4.32+0.60)	479(6.11+1.30)
Cx	65(2.12+0.90)	49(3.16+2.59)	114(5.29+3.49)
Ae	117(1.99+0.85)	86(3.23+2.49)	203(5.22+3.31)
Others	0	0	0
Total	438(5.90+2.45)	358(10.72+5.65)	796(16.62+8.10)
TW			
An	360(1.61+1.04)	144(2.91+2.29)	504(3.87+2.70)
Cx	140(1.88+0.95)	178(2.65+2.65)	318(4.15+2.74)
Ae	111(1.62+1.13)	129(3.73+1.98)	240(4.30+2.68)
Others	6(1.83+0.41)	0	6(1.83+0.41)
Total	617(6.95+3.52)	451(7.21+5.01)	1068(12.33+8.12)

Table 9: Multiple comparisons with Mosquito species LSD

Dependent Variable	(I) Mosquito specie	(J) Mosquito specie	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
EI (mm)	*Anopheles*	*Culex*	0.0321	0.04771	0.501	-0.062	0.1256
		Aedes	-.2259*	0.04963	0	-0.323	-0.1286
	Culex	*Anopheles*	-0.0321	0.04771	0.501	-0.126	0.0615
		Aedes	-.2580*	0.05291	0	-0.362	-0.1542
	Aedes	*Anopheles*	.2259*	0.04963	0	0.1286	0.3232
		Culex	.2580*	0.05291	0	0.1542	0.3617
LI(mm)	*Anopheles*	*Culex*	0.1148	0.10824	0.289	-0.098	0.3271
		Aedes	-0.1268	0.1126	0.26	-0.348	0.094
	Culex	*Anopheles*	-0.1148	0.10824	0.289	-0.327	0.0975
		Aedes	-.2416*	0.12004	0.044	-0.477	-0.0062
	Aedes	*Anopheles*	0.1268	0.1126	0.26	-0.094	0.3476
		Culex	.2416*	0.12004	0.044	0.0062	0.477

Based on observed means.
The error term is Mean Square (Error) = 4.404.
*. The mean difference is significant at the .05 level.

Discussion

4.1.1 Relative abundance and habitat of Species collected

The sites that were sampled had similar mosquito- dominated invertebrate community and there were no significant difference in the prevalence of collected mosquito larvae within the various micro habitats in support of our hypothesis that some areas might likely be devoid of some species of mosquitoes. A cursory look at the result of the mosquito larvae collected and identified indicated that *Anopheles* were more in number, followed by *Culex*, then *Aedes* and lastly unidentified species. This supports the work of Gillies and de

Meillon (1968) [26]; Gillies and Coetzee (1987) [27] that the species and their distributions and in particular Anopheline suggests that all species complex have sympatric distribution. The high number of Anopheles in all the areas supports the findings of Bruce-Chwatt (1951) [28] in which he concluded that *An. gambiae* ss is common in Nigeria because of its indiscriminate breeding habits such as domestic water containers, animal dinking places and any other breeding places created by man. But importantly, they are described as a highly endophilic, anthropophagous wet season vector (Gillies and Coetzee 1987) [27]

Of the five different microhabitats sampled, there were remarkably differences in their mosquito-dominated invertebrate community with a significant difference of P<0.05 established. Thus, our hypothesis that varying differences in habitat gradients with populations and community composition of mosquitoes may be important for understanding disease transmission in different kinds of microhabitats and may aid in planning more effective vector control strategies.

Accordingly, base on locations and habitat, whereas all the areas had the same types of mosquitoes, it was noted that the highest number of *Anopheles, Culex* and *Aedes* were collected at the TW, ARo and FG axis which are more suburb as compared to the other areas of AR and RR, although the analysis of variance revealed that in the distribution of the mosquito larva at various micro habitats, there is no significant differences but with respect to the abundance, there is significant difference between species identified at P<0.05 level of significance. This finding is supported by de Souza *et al*. (2010) who reported that the preferred breeding sites of the different mosquitoes and other environmental factors affect their distribution and prevalence of diseases they transmit. And as noted by Chen *et al*. (2007) [29], the relationship between these variables is partly due to the creation of breeding sites such as Costanzo *et al*. (2005) communicated that illegal dumping of tires in urban and wooded areas, wooded with declines in natural mosquito breeding sites (e.g. tree holes) have made discarded tires and important source of disease vectors. This influences the creation of breeding sites because mostly during the rainy season, tries have more water in them. Thus understanding the factors that regulate the size of mosquito populations is fundamental to the ability to predict transmission rates and vector population control (Service 1986) [30].

4.1.2 Relative Variation of Dates and locations in the Abundance of Mosquito Species

With regards to the relative variation of dates in respect to abundance of species, it is evident that in the three days of sampling i.e. on 30th March, 2015, 2nd April, 2015 and 22nd April, 2015, that although *Anopheles* species were collected in higher number when compared to the others but in particular, the varying dates also showed accordingly the highest number of recorded collected species of mosquitoes collected were on the 30th of march which marks the beginning of the rainy season although the analysis of variance revealed that there was a significant difference between dates and location of species identified at P<0.05 level of significance.. This supports what was noted by Gillet (1971), that warm moist weather favours the distribution of mosquitoes. The seasonality in mosquito abundance is as a result of increase or decrease in mosquito breeding places in different localities. Seasonal variations in mosquito abundance can be related to whether and hydrological conditions (Jaensen *et al*., 1986). In various areas with seasonal malaria transmission in Africa, Charlwood *et al*. (2000) [32] pointed out that it is possible to identify local reservoirs of transmission during the dry season. Identifying sources of mosquito larva during the dry season may provide a basis for selective larval control which may impact on subsequent malaria transmission in the rainy season (Sogoba *et al*., 2007) [22]. During the late dry season, temporary larval habitats are absent but as rainy season peaks larger water bodies increase in volume and velocity with detrimental effects on mosquito larval population. In determining mosquito breeding sites, seasonal rainfall is important. Adult vector densities are very low in the dry season but increase sharply at the onset of the rainy season (Sogoba *et al*., 2007) [22]. This can be attributed to the availability of breeding sites for mosquito and from where the environment is seeded with mosquito larval. Similarly, according to Lindsay *et al*. (1991) [33], permanent breeding sites during the dry season may serve to seed additional larval habitats formed during the rainy seasons. Therefore dry season larval control in the opinion of Fillinger *et al*. (2004) [34] might prevent this sharp increase and thus play an important role in integrated vector control strategies for instance; *Anopheles* species at different times tend to exploit different breeding habitats and peaks. For *An. gambiae,* abundance is most during the rainy season while *An. funestus* is predominant at the end of the rains and the beginning of the season (Coetzee *et al*., 2000) [35]. According to Costantini *et al*. (1999) [36], *An. funestus* follows in peak abundance after the vectors of *An. gambiae* complex, thus extending malaria transmission into the dry season similarly *An. arabiensis* and *An. moucheti* are mostly abundant in the early and late dry seasons, while *An. funestus* persists in the early and these periods. The occurrence of *An. funestus* persist in the early and late dry seasons until slow moving streams and cool shady places where they breed disappear (Oyewole *et al*., 2007) [37]. Thus, it supports our hypothesis that the presence of a pond or stream/river near a community support the presence of larvae which is critical for understanding processes affecting adult population

4.1.3 Relative Variation of Early and Late Instars at various Locations with Dates

The results showed the abundance of the early instars of mosquito larvae and late instars of mosquito larvae which would determine the rate of invasion to the human community. At locations AR, ARo and TW, more early instars of mosquito larvae were recorded showing the abundance of susceptibility to malaria except at locations RR and FG with lesser early instars of mosquito larvae and more late instars. Early instars of mosquito larvae shows more abundance than late instars of mosquito larvae at location AR on 2nd April, 2015 and 22nd April, 2015, at location RR on 22nd April, 2015, location FG on 22nd April, 2015, location ARo on 30th March, 2015 and 2nd April, 2015 and location TW on 30th March, 2015 and 22nd April, 2015 as shown in table 3.8. The analysis of variance further revealed that there was revealed that there are significant difference between early instars and late instars, dates and locations of species identified at P<0.05 level of significance. Thus it also supports our hypothesis that the presence of a pond or stream/river near a community support the presence of larvae which is critical for understanding processes affecting adult population. According to our third hypothesis, we deduced that association exists between early and late instars for individual species which is revealed in the difference of abundance in favour of early instars. This indicates oviposition is at a climax as compared to the survival of the larval stages.

4.2 Conclusion and Recommendation

Our study documents differences in the fauna associations with ponds/rivers in various microhabitats and found that topology of a particular area and cleanliness of individuals in a community could be important in explaining variation in populations of some mosquito species and in overall community patterns. The fact that these microhabitats have the same species of mosquitoes indicates that despite gradient or distance of the microhabitats, there is that possibility of travelling distance among the species of mosquitoes and/or the same edaphic factor common to all sampled areas that supports the invertebrate community. Additionally, the fact the same types of mosquitoes are found in ponds/rivers of the different microhabitats, could point to the assumption that in spite of species kinds, it appears most mosquitoes species are fast becoming generalist.

Understanding the abundance and prevalence of the early instars and late instars, location and dates are important determinants in understanding the pattern of composition of mosquitoes dominated invertebrate communities. From the results, we observed that there are significant difference in the prevalence of collected mosquito larvae within various microhabitats not in support of our hypothesis. It is further observed that there are significant difference in the distribution of mosquito larvae in various microhabitats not in support of our second hypothesis. According to our third hypothesis, we deduced that association exists between early and late instars for individual species which is revealed in the difference of abundance in favour of early instars. This indicates oviposition is at a climax as compared to the survival of the larval stages. In conclusion, it could be inferred that there is a great invasion of mosquitoes in the human community which calls for ease more funding to curtail health hazards that could come from mosquito bites.

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