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SPECIES COMPOSITION AND RELATIVE ABUNDANCE OF EXOPHILIC MOSQUITOES FROM KANO STATE, NORTHWEST-NIGERIA

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ABSTRACT
Exophilic mosquitoes are significant contributors to the spread of mosquito borne diseases. Their populations are increasing due to environmental changes like climate change, urbanization and deforestation. However, this study evaluate the species composition and relative abundance of exophilic mosquito in some parts of Kano State. Exophilic mosquitoes were collected once monthly for the period of twelve months from different sites including Darmanawa in Trauni LGA, Babban Gura in Makoda LGA and Unguwar Fulani in Wudil LGA using Cardboard boxes placed in an undisturbed area of two randomly selected households from 6 pm to 8 am. The mosquito species collected were identified morphologically to species level with aid of reported taxonomic guides. A total 520 mosquitoes were collected which were identified into 17 species across 5 genera. Higher significant ($p \leq 0.05$) species composition was observed among *Culex quinquefasciatus* (32.1%), *Culex pipiens* (28.7%) and *Anopheles gambiae* (16.9%) respectively. The study sites and season had significant ($p \geq 0.05$) effects on exophilic mosquito species composition. The relative abundance of exophilic mosquitoes was significant influenced by month ($F = 2.481$, $p \geq 0.05$), species ($F = 1.351$, $p \geq 0.05$), site ($F = 1.715$, $p \geq 0.05$) and season ($F = 1.181$, $p \geq 0.05$). Exophilic mosquito populations are diverse with peak of the collections in October and sites with greater degree of urbanization support higher abundance of the mosquitoes. Further study should be conducted to investigate the *Plasmodium* infection rates among these exophilic mosquito populations to assess their actual contribution to disease transmission

Keywords: Exophilic, Kano, Mosquito, Species composition, Relative abundance

INTRODUCTION
The worldwide shifts in insect communities occurs because of the ongoing human disturbance (Seibold *et al*., 2019), such as chemical pollution, habitat destruction and climatic change. Even though, many insects are vanishing many mosquito species are flourishing (Lambin *et al*., 2010). Recent studies suggested that anthropogenic activities can stimulate the population growth of several vector mosquito species (Jeanrenaud *et al*., 2019) and possibly facilitate the interactions between mosquito species (Roche *et al*., 2012), hosts (Lord *et al*., 2016), pathogens (Hauser *et al*., 2020).
Many studies on mosquitoes depend on resourceful sampling across different period or targeted sampling at location to increase collection (Schrama *et al*., 2020). Mosquitoes are important threat to human population and to the diversity of animals all over the globe and are precisely of concern in emerging countries of the world where the abundance and ecology of mosquitoes are only documented to some extent (Onodua *et al*., 2020).
Adult mosquitoes expend maximum of their existent resting outdoor in natural shelters such as caves, tree holes, and vegetation (Kawada *et al*., 2021). In a study by Hamid-Adiamoh *et al*. (2022), *Anopheles gambiae* s.s., *Anopheles coluzzii* and *Anopheles funestus* s.s. renowned endophilic vectors after being released indoor were recaptured outdoor, also from the recaptured assessment *Anopheles arabiensis* was found to be predominant mosquito species found resting outdoor.
Often overlooked, is the importance and size of the exophilic population species frequently resting within houses (Silver, 2008). Exophilic mosquito species that are malaria vectors could show off three basic types of exophily as considered by Gillies (1956); first are obligatory; Anopheles were obliged to rest in natural outdoor shelters due to the absence of man-made shelters, secondly are facultative; habitations of human and animals are available but adult mosquitoes rested within houses and natural outdoor shelters, thirdly are deliberate; mosquitoes desisted resting habitations despite available. This clarify the exophily behaviour for easy survey, as the part of the aim of present study which based on sampling facultative exophilic mosquito.
Mosquito abundance and composition can differ around location and the type of land use (Versteirt *et al*., 2013). Species composition is the identity and variety of different species that are existing in an ecological community (Fiveable, 2024). However, it covers not only the number of species but coupled with their relative abundance and the interactions between them (Fiveable, 2024). Also, Aggemyr *et al*. (2018) pointed that, species composition can be considered and described along species richness to achieve a more comprehensive understanding into the ecological processes in a particular environment.
Despite the crucial role exophilic mosquitoes played in the transmission of diseases such as malaria, dengue and yellow fever, there is a paucity of comprehensive data on their species composition and relative abundance in Kano State. The lack of understanding of their community structure hinders the development of targeted control strategies. The study hypothesized that exophilic mosquito species composition and relative abundance will be greater in the rural area.
This study aims to assess the exophilic mosquito populations in some parts of Kano State, with emphasis on their species composition and relative abundance. By elucidating the population structure of these mosquitoes, the study sought to provide valuable insight that can inform public health policies and vector management programmes, eventually contributing to the reduction of the mosquito populations and in turn reducing mosquito-borne diseases in the State.

MATERIALS AND METHODS

Study Area

Kano State is located between latitude 10° 3′ N and 12° 4′ N of the equator and between longitude 7° 4′ E and 9° 3′ E of the prime meridian (Mohammed *et al*., 2015). It covers a land area of 20,760 km² (Anonymous, 2021) and shares boundaries with Katsina State to the northwest, Kaduna State to the southwest, Jigawa State to the northeast, and Bauchi State to the southeast (Mohammed *et al*., 2015). The state is part of the Sudano-Sahelian zone of Nigeria (Aliyu *et al*., 2021) and is situated in northwestern Nigeria (Figure 1).

The vegetation in Kano primarily consists of Northern Guinea Savanna in the southern region, characterized by rich biodiversity, and Sudan Savanna in the remaining areas, which features sparse tree distribution, grasses, and shrubs (Aliyu *et al*., 2021).

Kano has a tropical and dry climate (Aliyu *et al*., 2021), with temperatures ranging from 15.8°C to 33°C, dropping as low as 10°C during the harmattan period. The state experiences two distinct seasonal periods: a wet season lasting five months (from May to September) and a dry season lasting seven months (from October to April). Average rainfall ranges from 63.3 mm ± 48.2 mm in May to 133.4 mm ± 59 mm in August (Visa *et al*., 2020)[21].

Study Sites Selection

The selection of the study sites for the collection of exophilic adult mosquitoes was done using two multi-stage sampling techniques (sampling frame and purposive sampling). A map of Kano State (Figure 1) and the stratification of 44 Local Government Areas (LGAs) into urban, semi-urban and rural by Kano State Gazette (2015) were utilized as sampling frame. In each of the three strata, one Local Government Area was selected as the primary sampling unit (PSU). These LGAs were purposefully selected based on the presence of significant mosquito breeding sites. The selected LGAs included Tarauni (urban), which has extensive drainage; Wudil (semi-urban), located near Wudil River; and Makoda (rural), which is adjacent to Tomas Dam. Within each Local Government Area, a ward was purposefully selected based on its proximity to the larger breeding site, and within each ward, a settlement was also purposefully chosen based on its closeness to the breeding site for the collection of resting adult mosquitoes (Table 1).

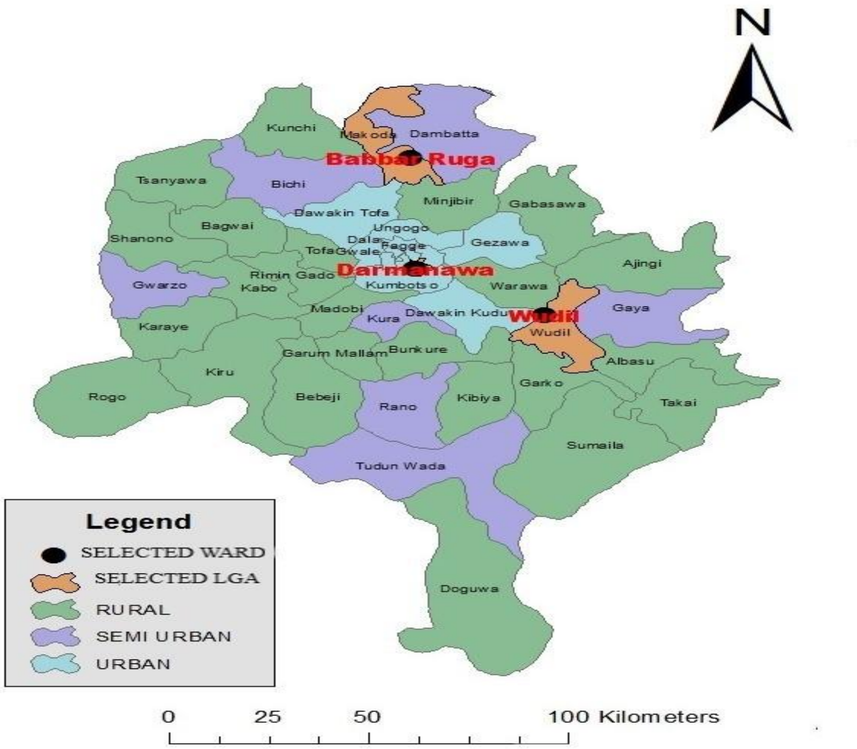

Figure 1: Map of Kano State Showing the Selected LGAs and Wards
Source: Diva-GIS Modified at the Department of Geography, Aliko Dangote University of Science and Technology, Wudil (September 7, 2023)

Study Design

A quantitative research design (longitudinal survey design) was employed for the collection and identification of mosquitoes resting outdoor. Mosquito collections were conducted once monthly for the period of 12 months in the selected ward that remained unchanged from August 2023 to July 2024, while the households sampled varied each month.

Exophilic Mosquito Sample Collections

Exophilic mosquitoes were collected using a modified version (in terms of the cardboard box demission and the positioning of the box) of the procedure described by Kweka *et al*. (2009). This method was chosen because it is effective for collecting species that habitually rest outdoors. During each collection, two households were randomly selected, and collections were conducted from 6:00 pm to 8:00 am. A cardboard box with dimensions of 35 cm in length, 37 cm in height, and 24 cm in width was used for the collection. The inside of the box was lined with black cloth (Figure 2). The box was positioned vertically in an undisturbed area of the household compound, with the entry point at the top. A piece of net was hung beside the entry point using a board pin, serving as a cover to prevent mosquito escape. To collect the trapped mosquitoes, the box was sprayed with Gongoni aerosol and left 10 minutes. The knocked-down mosquitoes were then collected using liner brush and placed into labelled petri-dishes containing silica gel. The samples were transported to the laboratory for sorting, morphological identification, and storage.

Figure 2: Artificial Cardboard Box Positioned at Collection Point

Morphological Identification of Mosquitoes

In the laboratory of Biology Department, Aliko Dangote University of Science and Technology Wudil Nigeria, the field samples of mosquito were mounted on an ELIKLIV digital LCD microscope, Model DM4 and identified morphologically to the species level using taxonomic keys from Becker *et al*. (2010), Ramberg (2017), Pecor (n.d.), Coetzee (2020), and WHO (2020).The Identification was based on colour, wing vein pattern and pale marks on body parts among other features. The frequency data of the identified species were recorded.

Determination of Species Composition and Relative Abundance of Exophilic Mosquitoes

The methodology developed by Jawuoro *et al*. (2017) was adopted to determine the composition of female mosquito species resting indoors and outdoors during the study period. This was accomplished using the formula below with slight modifications: the quadrants were replaced by variables relevant to the study, including months, study areas, resting places, and seasons. This method was selected because it effectively describes the structure of resting mosquitoes present in the study areas.

$$SC = \frac{n}{N} \times 100$$

Where SC is the species composition, n is the number of individual species per variable, while N is the total number of species within the same variable.

To assess the relative abundance of outdoor resting mosquitoes, the method described by Saurav (2017) was also adopted, with slight modifications. In this case, the quadrants were substituted with resting places. The recorded number mosquitoes was analyzed using the abundance formula outlined by Saurav (2017) below;

$$\text{Abundance} = \frac{Ni}{N}$$

Where Ni is the total number of individual of a species in all households, N is the total number of households in which the species occurred.

However, the relative abundance of outdoor mosquitoes was determined separately using the formula reported by Saurav (2017) below;

$$\text{Relative Abundance} = \frac{\text{Abundance of a species}}{\text{Abundance of all species}} \times 100$$

Data Analyses

The calculated values of species composition were subjected to Chi-square analysis at a significance level of 0.0 5 using SPSS 20 statistical software while the calculated values of relative abundance were evaluated using one-way analysis of variance (one-way ANOVA) at 0.05 significance level. Before the analysis, the normality of the data was assessed using the Shapiro-Wilk normality test (W = 0.8691) in PAST 4.03, which indicated that the data were not significantly normally distributed (p = 2.051 x 10-08). Consequently, the data were square root transformed. When the ANOVA indicated a significant difference, pairwise comparisons were conducted using the Least Significant Difference (LSD) post-hoc test in SPSS 20 statistical software.

Ethical Approval and Informed Consent

The study was ethically approved by Kano State Ministry of Health Research Ethics Committee, with approval number NHREC/17/03/2018, dated March 2, 2022.

Informed consent from the head of each household was obtained by having them complete a designated consent form prior to the commencement of mosquito collection. Households were also given the opportunity to withdraw from the research at any time they wished.

RESULTS AND DISCUSSION

Table 2 shows that a total of five hundred and twenty (520) exophilic mosquitoes were collected of which 211(40.6%) were caught in Darmanawa site, 195 (37.5%) in Babban Gura site and 114(21.9%) in Uguwar Fulani. The highest number of mosquito catch occurred in October with 74(14.2%) mosquitoes.

Based on morphological features, Seventeen (17) species across five (5) genera were identified. Higher composition was observed in *Culex quinquefasciatus* (32.1%), *Culex pipiens* (28.7%) and *Anopheles gambiae* (16.9%) respectively. The species composition of exophilic mosquitoes was significantly influenced by months (X^2 =711.459, $p \leq 0.05$) with highest species composition in October (14.2%) followed by November (12.5%) while the least was observed in May (3.8%) (Table 3).

Sites has significant effect on the species composition of exophilic mosquitoes (X^2 =230.310, $p \leq 0.05$). Darmanawa (40.6%) an urban settlement has the highest significant species composition while the least was recorded in Uguwar Fulani (21.7%) a semi-urban settlement (Table 4).

Season also shows a significant influence on the species composition exophilic mosquitoes (X^2 =93.421, $p \leq 0.05$). Dry season had the highest species composition (60.0%) than wet season (40.0%) (Table 5).

The relative abundance of exophilic mosquitoes was significant influenced by month ($F = 2.481, p \geq 0.05$), species

(F = 1.351, p ≥ 0.05), site (F = 1.715, p ≥ 0.05) and season (F = 1.181, p ≥ 0.05). Relative abundance across month was highest in February (6.33±1.30) and lowest in March (3.81±0.98) (Table 6).

The relative abundance within species of exophilic mosquito was recorded highest with *Aedes geniculatus* (7.07±0.00) and the lowest was recorded with *Mansonia uniformis* (2.55±0.00) (Table 7).

Table 7 shows that the relative abundance of exophilic mosquitoes was slightly higher in Darmanawa site (5.51±1.56) than in Babban Gura (5.17±1.69) and Uguwar Fulani (5.11±2.13) while season shows slightly higher relative abundance dry season (5.36±1.88) than wet season (5.15±1.71).

Table 1: Description of Study Sites for Collection of Exophilic Mosquito Species in Kano State

LGA	Area (Km^2)	Latitude (°N)	Longitude (°E)	Cluster	Ward	Sampling Area (Settlement)
Tarauni	28	11.95862	8.54429	Urban	Darmanawa	Darmanawa (behind Hassan Gwarzo Secondary School)
Wudil	362	11.72959	8.81859	Semi-urban	Wudil	Unguwar Fulani (behind ADUSTECH)
Makoda	441	12.419	8.233	Rural	Babban Ruga	Babban Gura (behind Audu Bako College of Agriculture)

LGA = Local Government Area, Km^2 = Kilometre square, °N = Degree North, °E = Degree East.
Sources: latitude and longitude from Latitude.to (2023) and Area from VisitKano (2023).

Table 2: Frequency and Percentage of Exophilic Mosquito Catch from Selected Sites in Kano State

Month	Babban Gura(%)	Darmanawa(%)	Unguwar Fulani(%)	Total (%)
August	16(3.1)	13(2.5)	9(1.7)	38(7.3)
September	44(8.5)	10(1.9)	6(1.2)	60(11.5)
October	28(5.4)	38(7.3)	8(1.5)	74(14.2)
November	27(5.2)	35(6.7)	3(0.6)	65(12.5)
December	3(0.6)	12(2.3)	9(1.7)	24(4.6)
January	5(1.0)	31(6.0)	5(1.0)	41(7.9)
February	2(0.4)	17(3.3)	10(1.9)	29(5.6)
March	17(3.3)	26(5.0)	12(2.3)	55(10.6)
April	8(1.5)	6(1.2)	10(1.9)	24(4.6)
May	6(1.2)	5(1.0)	10(1.9)	21(4.0)
June	18(3.5)	4(0.8)	11(2.1)	33(6.3)
July	21(4.0)	14(2.7)	21(4.0)	56(10.8)
Total	195(37.5)	211(40.6)	114(21.9)	520(100)

Table 3: Species Composition (%) of Exophilic Mosquito across Month Collection from Selected Sites in Kano State

	Months												
Mosquito Species	**A**	**S**	**O**	**N**	**D**	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**Total MSC**
Aedes atropalpus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.3	5.3	0.0	0.0	0.6
Aedes geniculatus	0.0	0.0	0.0	0.0	0.0	0.0	3.4	0.0	0.0	0.0	0.0	0.0	0.2
Anopheles annularis	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.1	0.0	0.0	0.0	0.0	1.0
Anopheles funestus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.6	0.4
Anopheles domicolus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.0	0.0	0.0	0.2
Anopheles gambiae	39.5	46.7	14.9	3.1	0.0.	0.0	0.0	0.0	33.3	10.0	20.6	26.8	16.9
Anopheles nigerrimus	0.0	0.0	0.0	0.0	0.0	2.4	0.0	0.0	0.0	0.0	0.0	0.0	0.2
Culex erythrothorax	0.0	0.0	0.0	0.0	20.8	0.0	0.0	1.8	0.0	0.0	0.0	0.0	1.7
Culex pipiens	5.3	25.0	29.7	46.2	54.2	41.5	51.7	18.2	29.2	5.0	20.6	17.9	28.7
Culex quinquefasciatus	55.3	26.7	54.1	49.2	16.7	4.9	27.6	20.0	4.2	40.0	14.7	33.9	32.1
Culex tarsalis	0.0	1.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2
Culex theileri	0.0	0.0	0.0	0.0	4.2	24.4	0.0	23.6	0.0	0.0	0.0	5.4	5.2
Culex torrentium	0.0	0.0	0.0	1.5	0.0	0.0	17.2	25.5	25.0	30.0	35.3	8.9	9.4
Culex tritaeniorhynchus	0.0	0.0	0.0	0.0	0.0	0.0	0..0	1.8	0.0	0.0	5.9	0.0	0.6
Culex univittatus	0.0	0.0	0.0	0.0	4.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2
Culiseta inornata	0.0	0.0	0.0	0.0	0.0	26.8	0.0	0.0	0.0	5.0	0.0	0.0	2.3
Mansonia uniformis	0.0	0.0	1.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2
Total	7.3	11.5	14.2	12.5	4.6	7.9	5.6	10.6	4.6	3.8	6.5	10.8	100

Table 3: Species Composition (%) of Exophilic Mosquito Based on Sites from Selected Sites in Kano State

Mosquito Species	Sites			Total Mosquito Species Composition
	Babban Gura (%)	Darmanawa (%)	Unguwar Fulani (%)	
Aedes atropalpus	0.5	0.0	1.8	0.6
Aedes geniculatus	0.5	0.0	0.0	0.2
Anopheles annularis	2.6	0.0	0.0	1.0
Anopheles funestus	0.0	0.0	1.8	0.4
Anopheles domicolus	5.0	0.0	0.0	0.2
Anopheles gambiae	41.8	1.9	1.8	16.9
Anopheles nigerrimus	0.5	0.0	0.0	0.2
Culex erythrothorax	0.5	1.9	3.5	1.7
Culex pipiens	17.3	35.1	36.3	28.7
Culex quinquefasciatus	26.5	37.9	31.0	32.1
Culex tarsalis	0.0	0.0	0.9	0.2
Culex theileri	1.5	10.9	0.9	5.2
Culex torrentium	6.6	6.6	19.5	9.4
Culex tritaeniorhynchus	0.0	0.0	2.7	0.6
Culex univittatus	0.0	0.5	0.0	0.2
Culiseta inornata	0.5	5.2	0.0	2.3
Mansonia uniformis	0.5	0.0	0.0	0.2
Total	37.7	40.6	21.7	100

Table 4: Species Composition (%) of Exophilic Mosquito Based on Seasons from Selected Sites in Kano State

Mosquito Species	Season		Total Mosquito Species Composition
	Dry (%)	Wet (%)	
Aedes atropalpus	0.6	0.5	0.6
Aedes geniculatus	0.3	0.0	0.2
Anopheles annularis	1.6	0.0	1.0
Anopheles funestus	0.0	1.0	0.4
Anopheles domicolus	0.0	0.5	0.2
Anopheles gambiae	6.7	32.2	16.9
Anopheles nigerrimus	0.3	0.0	0.2
Culex erythrothorax	1.9	1.4	1.7
Culex pipiens	36.5	16.8	28.7
Culex quinquefasciatus	31.4	33.2	32.1
Culex tarsalis	0.0	0.5	0.2
Culex theileri	7.7	1.4	5.2
Culex torrentium	8.3	11.1	9.4
Culex tritaeniorhynchus	0.3	1.0	0.6
Culex univittatus	0.3	0.0	0.2
Culiseta inornata	3.5	0.5	2.3
Mansonia uniformis	0.3	0.0	0.2
Total	60.0	40.0	100

Table 5: Relative Abundance (%) of Exophilic Mosquito across Months from Selected Sites in Kano State

Months	Mean±Standard Deviation
August	6.26±2.10
September	5.94±1.60
October	5.89±1.82
November	6.12±2.51
December	5.69±2.43
January	5.85±1.94
February	6.33±1.30
March	3.81±0.98
April	5.56±0.83
May	5.18±1.89
June	5.04±1.44
July	4.29±1.32

Table 6: Relative Abundance (%) of Exophilic Mosquito within Species from Selected Sites in Kano State

Mosquito Species	Mean±Standard Deviation
Aedes atropalpus	4.82±0.50
Aedes geniculatus	7.07±0.00
Anopheles annularis	4.76±0.00
Anopheles funestus	2.95±0.00
Anopheles domicolus	4.47±0.00
Anopheles gambiae	5.34±1.85
Anopheles nigerrimus	4.50±0.00
Culex erythrothorax	3.84±0.90
Culex pipiens	5.85±1.97
Culex quinquefasciatus	5.71±1.72
Culex tarsalis	5.00±0.00
Culex theileri	4.45±1.41
Culex torrentium	5.06±1.77
Culex tritaeniorhynchus	3.16±0.87
Culex univittatus	3.54±0.00
Culiseta inornata	5.12±0.92
Mansonia uniformis	2.55±0.00

Table 7: Relative Abundance (%) of Exophilic Mosquito based on Sites and Seasons from Selected Sites in Kano State

Variables	Mean±Standard Deviation
Sites	
Babban Gura	5.17±1.69
Darmanawa	5.51±1.56
Unguwar Fulani	5.11±2.13
Season	
Dry	5.36±1.88
Wet	5.15±1.71

Discussion

The notable findings from this study, is the first to report the identification of *Culex tarsalis*, *Culex erythrothorax*, *Culex tritaeniorhynchus*, *Culex torrentium*, *Anopheles nigerrimus*, *Anopheles domicolus*, *Anopheles annularis*, *Aedes atropalpus*, and *Aedes geniculatus* resting outdoors from Kano State at morphological level. Accurate identification of mosquito populations is crucial for vector control, as it establishes reference information for selecting the most effective tools and monitoring of mosquito species (Müller *et al*., 2013). Other mosquito species identified in the present study include *Anopheles funestus*, *Anopheles gambiae*, *Culex univittatus*, *Culiseta inornata*, *Culex pipiens*, *Culex quinquefasciatus*, *Mansonia uniformis* and *Culex theileri*. These findings align with those of Oguoma and Ikpeze (2008), who also reported the identification of the *Anopheles gambiae* complex, *Anopheles funestus* complex, *Culex quinquefasciatus*, *Culex pipiens* pipiens, *Culex pipiens* Fatigans, *Mansonia* spp., and *Psorophora* spp. among the mosquitoes they collected in parts of Kano State. Similarly, Yayock *et al*. (2021) reported the identification of *Culex quinquefasciatus*, *Culex tritaeniorhynchus*, *Culex univittatus*, *Culex pipiens*, and *Anopheles gambiae* in Kaduna Metropolis. These similarities could be attributed to similar vegetation zone where the studies were carried out.

Species composition can be considered and described along species richness to achieve a more comprehensive understanding into the ecological processes in a particular environment (Aggemyr *et al*., 2018). Number of missing species from a community sample can be predict through species composition when extensive data are available (Fagan and Kareiva, 1997). Monitoring the species composition in a given country is one of the most significant stages concerning the prevention of mosquito borne diseases, also collecting information on the distribution, abundance and seasonality of mosquito vector is one of the utmost crucial stages in surveillance (Muja-Bajraktari *et al*., 2019). In this study higher mosquito catch were recorded in September, October and November and this coincide with higher species composition of exophilic mosquitoes. This support the findings of Onyango *et al*. (2020) who reported that increased temperatures decrease adult mosquito longevity and increase mortality. Kano climate is tropical and dry type, with temperature ranging between 15.8°C and 33°C, but it drops to as low as 10°C during the harmattan period (Aliyu *et al*., 2021). The reported months with high proliferation of exophilic mosquitoes were within the harmattan period.

The higher composition of *Culex quinquefasciatus*, *Culex pipiens* and *Anopheles gambiae* recorded in study was similar with some findings from neighbouring states, including that of Dalhatu *et al*. (2016) who reported *Culex quinquefasciatus* (57.89%), *Culex molestus* (25.87%) *and Culex pipiens* (7.62%) *Anopheles gambiae* s.l. (0.82%) in some part of Bauchi State. Yayock *et al*. (2021) in their study of mosquito species composition in Kaduna State metropolis presented *Culex quinquefasciatus* (72.8%) *Culex toroensis* (12.05%), *Culex tritaeniorhnchus* (3.05%), *Culex whitmorei* (0.49%), *Culex univittatus* (0.01%), *Culex pipiens* (4.4%), *Culex simpsoni* (0.03%), *Culex poicilepes* (0.10%), *Aedes aegypti* (4.8%), *Culex andersoni* (0.54%), *Culex duttoni* (0.67%), *Culex jacksoni* (0.06%) and *Anopheles gambiae* (0.98%). Two mosquito species *Culex quinquefasciatus* (96.77%) and *Anopheles gambiae* (4.23%) were encountered in an investigation of indoor resting density of mosquitoes in a part of Bayelsa State (Ebenezer and Woyinzuosindor, 2019).

Urban settlement (Darmanawa) had the highest composition of exophilic mosquitoes and this could be attributed to urbanization that led to the destructions of their natural resting places. In the current study higher significant composition of exophilic mosquito was recorded during dry season. Irikannu *et al*. (2023) reported decreasing population of adult mosquito in the month of August (mid of wet season) ahead of its climax in September. This could be due to flooding and recurring rainfall that temporally flush out mosquito eggs from the breeding ground.

The relative abundance of different species have been key measures for assessing ecological communities (Billheimer *et al*., 2001). This study recorded no differences in relative abundance of exophilic mosquitoes with respect to month, among the identified species, sites and season. Although, *Aedes geniculatus* (7.07%) has the highest relative abundance but the composition of this species is only 0.2%. Wood (2006) noted that using relative abundance data can lead to overdispersion.

CONCLUSION

Exophilic mosquito samples collected demonstrate a diverse mosquito population with 17 species identified across 5 genera. The peak of the collections was in October, and Darmanawa had highest number of mosquito collection. Mosquito species composition is strongly influenced by temporal and spatial factors such as month, location and season with *Culex quinquefasciatus* being the most prevalent species. The relative abundance of mosquitoes indicates that both temporal and spatial factors as well as species-specific trait did not play significant roles in determining the population level of exophilic mosquitoes. However, *Aedes geniculatus* is prominent species among the less abundant mosquito populations in the study sites.

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