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Species Composition and Distribution of *Anopheles* Mosquito Vectors in Kontagora, Niger State, Nigeria

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ABSTRACT: *The endemicity of malaria in any locality in determine by indigenous Anopheles species composition, distribution as well as Plasmodium infectivity. This research was conducted to determine the species composition and distribution of Anopheles mosquito vectors in Kontagora, Niger State Nigeria. Adult mosquitoes were collected from five (5) sampling sites widely located in Kwangwara, Tudun wada, Dadin kowa, Sabon gari and Usubu areas of Kontagora metropolis. Collected mosquitoes were taken and examined in the laboratory, sorted into Anopheles and identified into species using standard taxonomic keys and Polymerase Chain Reaction (PCR) techniques respectively. Data generated were analysed using the Statistical Package for Social Scientists (SPSS) software version 20.3 and excel package. Anopheles species composition was expressed as the percentage of total Anopheles mosquitoes collected. Chi-square test was used to compare the results from the five sampling locations. The results of the study revealed six (6) Anopheles species; namely An. gambiae, An. funestus, An. squamosus, An. coustani, An. nili and An. maculipalpis, whose distribution varied significantly ($p < 0.05$) between sampling locations with An. gambiae predominating. Findings therefore revealed the preponderance of Anopheles gambiae species, indicating high malaria transmission potentials in the study area. This underscores the importance of generating intensive spatio-temporal information on the risk factors associated with malaria transmission on a local scale.*

KEYWORDS: species, composition, distribution, *anopheles,* mosquito vectors.

INTRODUCTION

Mosquitoes of the family Culicidae are considered a nuisance and a major public health problem because their females feeds on human blood and thus transmit extremely harmful diseases, such as malaria, yellow fever and filariasis (Lamidi *et al.*, 2017). *Anopheles* species have plagued the world with malaria for many decades and centuries. Sub-Saharan African is home to 90% of malaria cases and 91% of malaria deaths globally (WHO, 2017). The distribution pattern, transmission and intensity of the disease are dependent on the degree of urbanization and the distance from vector breeding sites (CDC, 2015). The endemicity of malaria in any region is determine by indigenous *Anopheles* mosquito abundance, feeding, resting behaviour and their *Plasmodium* infectivity, among other factors (Lamidi *et al.*, 2017). Environmental, social and demographic factors such as climate change/variability drive the distribution of the dominant malaria vector species and their parasite transmission (Akpan, 2015). Species distribution varies in response to changes in temperature and precipitation.

There are approximately 3,500 species of mosquitoes grouped into 41 genera (WHO, 2013). Human malaria is transmitted only by females of the genus *Anopheles*. Of the approximately 430 *Anopheles* species, only 30-40 transmit malaria (i.e., are vectors) in nature (WHO, 2016). Various species have been found to be vectors in different parts of the world, but *Anopheles gambiae* is the chief vector in Africa (WHO, 2013). Malaria prevention has become so difficult in Nigeria. This is because the species composition and distribution and other biological parameters of the mosquitoes are poorly known especially in malaria endemic areas. Therefore, understanding the temporal and spatial determinants of parasite transmission, its seasonal patterns and the dominant vectors implicated in transmission is crucial for the control of vector species. It is on this premise that this study is design to provide local data on species composition and distribution of *Anopheles* vectors in Kontagora with the view to facilitate the targeting of the incriminating species thereby improving the preciseness of the control strategy.

MATERIALS AND METHODS

Study Area

Kontagora town is situated at 10.4 ^{0} North latitude, 5.47 ^{0} East longitude and 335 meters' elevation above sea level with an estimated population of over 200,000 inhabitants located at the south bank of Kontagora River. The area has a tropical climate with mean annual temperature, relative humidity and rainfall of 30.20 ^oC, 61.00 % and 1334.00 mm, respectively. The climate presents two distinct seasons; a rainy season between May and October, and a dry season between November and April.

Sampling locations

Adult mosquito samples were collected from five sampling sites located in Kwangwara, Sabon Gari, Tudun Wada, Dadin Kowa and Usubu areas of Kontagora town. Two houses were randomly selected per area, coded and used as sampling points for indoor and outdoor collections of adult mosquitoes. Two rooms were selected from each house for indoor collection and the number of occupants in each room determined.

Adult Mosquito Collection

Indoor mosquitoes were collected using the Pyrethrum Spray Catch (PSC) between the hours 06:00 am and 09:00 am in the study areas. Large white sheets of clothes were spread from wall to wall to cover the floors of the room while all doors and windows were shut.. After about 20 minutes, the spread cloths were carefully folded starting from the corners. Knock down mosquitoes were collected with forceps into a damp petri dish. Outdoor mosquitoes were collected using CDC light traps. These traps were set from 7.00 pm and retrieved at 7.00 am). Individual samples were preserved in dry silica gel in well labelled Eppendorf tubes (1.5 ml) prior to identification.

Morphological Identification

Anopheline were separated from Culicine mosquitoes according to the morphological characteristics of their maxillary palps and identified mosquito genera were sexed based on the presence or absence of plumose (feathery) antennae. The morphological identification of different species of female *Anopheles* was done by studying the scales and colour of the palps at the head region, the patterns of spots on the wings, thorax, terminal abdominal segments, scales of the legs using dissecting microscope following the taxonomic keys of Gillett and Smith (1972) and Gillies and Coetzee (1987). The wings and legs of the *Anopheles gambiae* were separately preserved in PCR tube for molecular identification of the sibling species.

Molecular Identification of *Anopheles* Species

The multiplex PCR technique was used for molecular characterization of members of the *An. gambiae* complex as described by Okwa *et al*. (2007), Brogdon and Chan (2010) and Kabbale *et al.* (2016). Direct method was used where legs and (or) wings of each morphologically identified member of *An. gambiae* complex were placed in PCR tube/sample templates covered with reaction mixture. A 12.5 ul reaction mixture was prepared. This contained 4 ul of master mix (DNA polymerase, reaction buffer, 7.5 ml MgCl2 and 1 ml of dNTPs), gently vortexed for homogenization and briefly centrifuged after thawing, 6.15 ul of deionized distilled water and 0.5 ul of multiple sets of species-specific primers *(An . melas, An . gambiae ss, An . arabiensis*) and 0.25ul of *An . quadrian nulatus* primers and universal primer for the amplification of several targets in a single PCR experiment of each Anopheles complex (Kabbale *et al* ., 2016). Thereafter, 12.5 ul of reaction mixture was added to each of the mosquito samples in the PCR tubes. Each of the tubes was loaded in the PCR machine and programmed. Samples were run on a rotor-gene 6000 using the temperature cycling conditions as follows: Heated lid at 110OC and initial denaturation at 95OC for 3 minutes, followed by 30 cycles of denaturation at 95OC for 30 seconds, annealing at 55oC for 30 seconds and extension at 72oC for 40 seconds, then followed by final extension at 72OC for 7 minutes and final hold at 8oC.

Data Analysis

Data generated were analysed using the Statistical Package for Social Scientists (SPSS) software version 20.3 and excel package. *Anopheles* species composition was expressed as the percentage of total *Anopheles* mosquitoes collected. Chi-square test was used to compare the results from the five sampling locations.

RESULTS AND DISCUSSIONS

Results

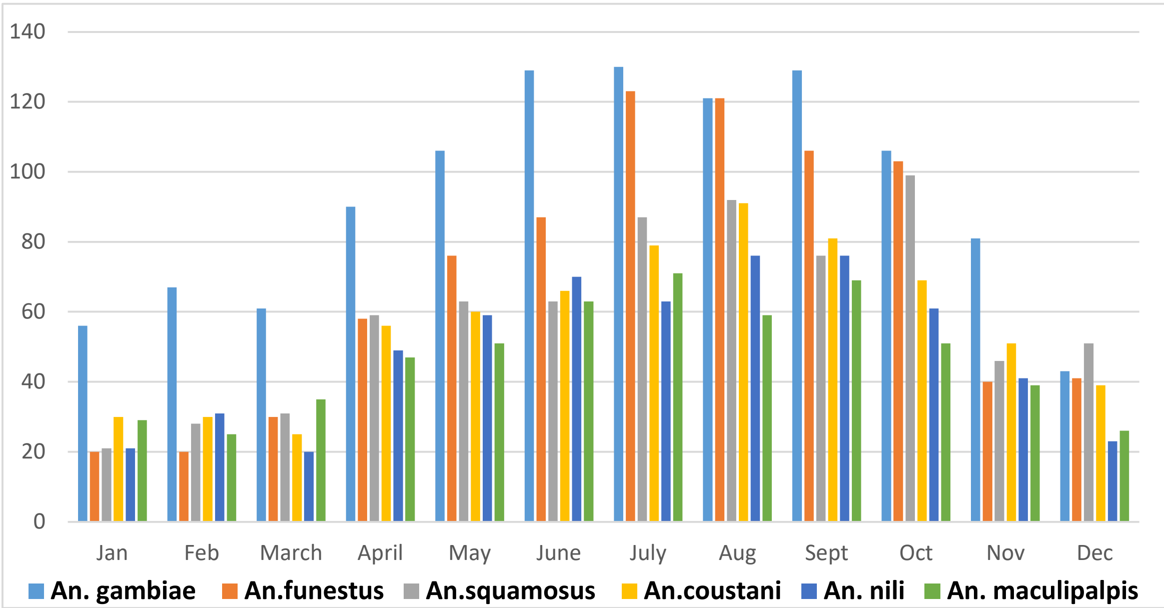
Six (6) species of *Anopheles* mosquitoes were found to co-exist in Kontagora; namely *Anopheles gambiae, An. funestus, An. squamosus, An. coustani, An. nili* and *An. maculipalpis.* Of the six (6) species encountered, *Anopheles gambiae* was the dominant species constituting 24.9 % of *Anopheles* population in the study area. This was followed by *An. funestus* 18.4 %, *An. squamosus* 15.9 %, and *An. constani* 15.1 % *An. maculipalpis* 13.8 %) and *An. nili* 11.9% as presented in Table 4.5. Spatial distribution of these species revealed that *Anopheles gambiae* occurred more abundantly in Kwangwara 21.98 % with the lowest occurrence in Tudun wada 17.96 %. *An. funestus* occurred more abundantly in Usubu area 22.5 %. Similarly, Kwangwara area produced more vectors *of An. Squamosus*, (26.4 %), *An. nili* (23.8 %) and *An. maculipalpis* 30.6 %. *An. coustani* on the other way occurred more abundantly in Tudun wada area 22.2 %. On a general note, Kwangwara area produced more *Anopheles* mosquitoes 23.6 % while Usubu area produced the least 18.4 %. The distribution of *Anopheles* species however varied significantly ($p<0.05$) between sampling location. The occurrence and distribution of the six (6) *Anopheline* species varied between months. While the occurrence of all the six (6) species seems to rise between the months of April and November, a sharp drop in their abundance was observed between the months of December and March. Monthly species abundance showed that *An. gambiae* and *An. funestus* which are the leading malaria vectors in Nigeria strive more in July, while An. *squamosus* and *An. coustani* occurred more abundantly in August. *An. nili* maintained high occurrence in August and September and *An. maculipalpis* occurred more only in September. All the species strived better in wet season compared to the dry season.

Table 1: Spatial Distribution of *Anopheles* Mosquito Species in Kontagora.

Sample location/specie	*An. Gambiae*	*An. funestus*	*An. Squamosus*	*An. Coustani*	*An. nili*	*An. maculipalpis*	Total
Kwangwara	246 (21.9)*	161 (19.5)	189 (26.4)	146 (21.6)	127 (23.8)	190 (30.6)	1,059 (23.6)
Tudun wada	201 (17.9)	147 (17.8)	143 (19.9)	150 (22.2)	101 (18.9)	145 (23.3)	887 (19.7)
Sabon gari	207 (18.5)	169 (20.5)	132 (18.4)	141 (20.8)	123 (23.0)	92 (148)	864 (19.2)
Dadin kowa	236 (21.1)	162 (19.6)	121 (16.9)	120 (17.7)	99 (18.5)	177 (18.8)	855 (19.0)
Usubu	229 (20.5)	186 (22.5)	131 (18.3)	120 (17.7)	84 (15.7)	77 (12.4)	827 (18.4)
Aggregate	1,119 (24.9)	825 (18.4)	716 (15.9)	677 (15.1)	534 (11.9)	621 (13.8)	4,492

***Values in parenthesis are percentage proportions along a column**

Figure. 1: Monthly distribution of Anopheline Species in Kontagora



DISCUSSION

The effective control of malaria through vector management requires information on distribution and species composition of Anopheline vectors in a targeted area. Therefore, mapping species distribution in heterogeneous environment is necessary for a successful control involvement. In this study, six (6) species of *Anopheles* mosquitoes were found; namely *Anopheles gambiae* (24.9), *An. funestus* (18.4), *An. squamosus* (15.9), *An. coustani* (15.1), *An. nili* (11.9) and *An. maculipalpis* (13.8) with *An. gambiae* having the highest abundance.

The various species of *Anopheles* mosquitoes encountered during the study period occurred in variable proportions depending on the month and site of collection. The study observed that *Anopheles gambiae,* the principal vector of malaria was the most ubiquitous of all *Anopheles* mosquitoes in Kontagora and occurred more abundantly in Kwangwara area more than the other sampling locations. *Anopheles gambiae* has been reported as the dominant and most efficient vector of human malaria in the Afrotropical Region (CDC,2015; Sinka *et al.*, 2010) based on its high abundance, longevity, high propensity for human feeding, and high vectorial capacity (Autino *et al.*,2012). Arum (2021) recorded very high abundance of indoor resting adult *Anopheles gambiae* over *An. funestus, An. coustani* and *An. pharoens* is in a semi-arid ecosystem of Baringo district, Kenya.

However, the predominance of *An. coluzzii* in some parts of North Central Nigeria was reported by Aju-Ameh *et al*. (2017) in Benue state and Oduola *et al* . (2016) in Kwara State. Anosike *et al*. (2007) also reported the occurrence of *An. constani* as a major species in Imo state. The abundance of these species of mosquito is attributed to the fact that these mosquito species are associated with human dwellings with indoor resting habits and the species are mainly anthropophilic (Oyewole *et al.*, 2005). In an earlier study, Lamidi *et al*.(2017) identified twenty (20) species of *Anopheles* mosquitoes in three selected areas of Taraba State with *Anopheles coluzzii* as the most dominant species in all the three areas thus; *Anopheles coluzzii*, *An. rivulorum* , *An. constani*, *An. salbaii*, *An. gambiae*, *An. rufipes*, *An. garhami*, *An. gambiae* M and S hybrid, *An. aruni*, *An. maculipalpis*, *An. Pharoensis*, *An. rhodensiensis*, *An. funestus*, *An. tenebrosus*, *An. caliginosus*, *An. concolor*, *An. nili*, *An. hancoki*, *An. arabiensis* and *An. pariensis*.

The variability in the distributions of *Anopheles* species in the study area will have significant influence on malaria transmission and epidemiology. However, land use reflecting high urbanization, increased population density and anthropogenic activities are important environmental variables that affects vector distribution and malaria transmission dynamics. The critical influence of land use dynamics in the occurrence and distribution of *An. gambiae* s.l., *An. gambiae* s.s. and *An. arabiensis* is expressed in their high distribution density in highly populated/urbanized states with increased anthropogenic activities including Abia, Akwa Ibom, Anambra, Enugu, Imo, Kano, Lagos, Ogun, Ondo, Osun, Oyo, Rivers and Sokoto states of Nigeria (Akpan *et al.*, 2018). Because *An. gambiae* were more abundant in the wet months, followed by *An. funestus,* the two species seem to complement one another in sustaining malaria endemicity in Kontagora. This is in line with Kigadye *et al*. (2010), Alam *et al.* (2012) and Ebenezer *et al.* (2014). Moiroux *et al.* (2014) also reported that *An. gambiae* s.s. was responsible for malaria transmission during wet season. Akpan *et al.,* (2018) also explained that total annual precipitation strongly influence the range and relative abundance of *An. arabiensis* and *An. gambiae* within forest zones and savannas with *An. arabiensis* predominating during the dry season and *An. gambiae* becoming more abundant during the rainy season.

The occurrence of *An. coustani* and *An. nili* in Kontagora is consistent with the report of their occurrence in Benue and Kwara states, Nigeria by Aju-Ameh *et al.* (2017) and Oduola *et al.* (2016), respectively. *Anopheles nili* was the least abundant species in Kontagora and also reported by Lamidi *et al*. (2018) as the least in Taraba state; perhaps because *An. nili* are known to be common in humid/ montane regions (Wanji *et al*., 2003).

CONCLUSION

The study revealed six (6) species of *Anopheles* mosquitoes in Kontagora occurring in variable proportions depending on the month and site of collection. The study observed that *Anopheles gambiae,* the principal vector of malaria was the most ubiquitous of all *Anopheles* mosquitoes in Kontagora.The composition of *Anopheles* mosquito species found in the study area is of public health concern. This calls for further investigation and review of policies and management strategies based on emerging knowledge in this locality.

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