

Entomological and parasitological indices of malaria transmission in Tungan-Goro and Gbaiko communities in Minna, Niger State, Nigeria

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Abstract

In Nigeria, malaria is highly prevalent, most especially in Minna, Niger State. This study was carried out to determine the entomological and parasitological indices of malaria transmission in two communities, namely, Tungan-goro and Gbaiko in Minna, Niger State, Nigeria. Collection of the mosquito was carried out using the Pyrethrum Spray Catch (PSC). The population's indoors were sampled by spreading on the floor for mosquito collection, white sheet (5m x 5m) with the edge held to the wall by masking tape. The room was sprayed with pyrethroid insecticide (Baygon) and then left for 10 minutes, with every opening shut. Out of the total number (742) of mosquitoes collected, *Anopheles* sp. had a relative abundance of 456 (61.50%) with 273 (59.90%) females and 183 (40.10%) males. *Culex* sp. had a relative abundance of 286 (38.50%) out of which 155 (54.20%) were females and 131 (45.80%) were males. At both study locations *Anopheles* sp. were more in number compared to *Culex* sp. Out of the 365 female *Anopheles* mosquitoes dissected for parity, 211 (67.00%) were parous, while 104 (33.00%) were nulliparous. Out of 445 blood samples examined for malaria parasite 315 (70.80%) were positive while 130 (29.20%) were negative ($p < 0.05$). This study provides useful baseline data for designing strategies for the control of mosquito-borne diseases in Minna and its environs.

Keywords: pyrethroid, diversity, abundance, *Anopheles* sp., *Culex* sp.

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Introduction

Despite advances in the treatment and prevention, over the past decades, malaria still threatens the lives of millions in tropical countries. Over the years, increasing use of insecticide treated nets, indoor residual spraying, and early treatment with Artemisinin-based Combination Therapies (ACT's) has led to a reduction in morbidity and mortality caused by malaria in some African countries. An impediment to this progress is the ability of the parasite to develop resistance to anti-malarial drugs and increasing insecticide resistance of the mosquito vectors.

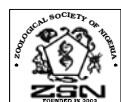
Malaria is transmitted by female mosquitoes in the genus *Anopheles* because they support the sporogonic development of human malaria parasites (Beier *et al* 1998). There are over 2,500 species of *Anopheles* mosquitoes, but less than 50 are capable of transmitting malaria. In some cases, different forms are found in varying ecological regions, thus the need to identify the prevalent malaria vectors in the study locations.

According to the World Health Organization (WHO), malaria is the world's most important parasitic disease with an estimated case of 247 million resulting in 881,000 deaths most of them children under the age of five (WHO, 2008). The Federal Ministry of Health (FMOH) also reports that malaria accounts for 25 percent of infant mortality and 30 percent of childhood mortality in Nigeria (FMOH, 2009).

Malaria is endemic throughout Nigeria with a high percentage of the population at risk. It poses a major threat to over 2.4 billion people which is about 4% of the world population. Indeed malaria is a major public health problem worldwide. In Africa more than \$12 billion is lost to malaria annually thus reducing the Gross Domestic Product (GDP) and contributes to a great extent to the poverty situation in Africa, as it exerts a negative influence on the productivity of households in Africa. Malaria is a persistent ailment in tropical Africa especially among under five children due to their low level of resistance to the disease and mortality to it amounts to millions (WHO, 2007).

Malaria transmission in these African communities is enhanced by suitable environmental conditions such as high humidity and warmth which accelerates mosquito development. Poor housing quality also facilitates malaria transmission as the population are continually exposed to mosquito bites. In communities where the use of mosquito-treated nets is implemented, this offers protection from the mosquitoes although bites can still occur outside the house (Gulleko and Coluzzi, 1993).

Plasmodium falciparum is responsible for most malaria-related deaths worldwide and is the predominant *Plasmodium* sp. in sub-Saharan Africa. Transmission intensity and population at risk vary substantially between



and within countries (Abeku *et al* 2004). Of the 2.4 billion people at risk of *falciparum* malaria, 70% live in areas of unstable or low endemic risk. Almost all populations at medium and high levels of risk live in sub-Saharan Africa, where the burden of disease, death and disability from *falciparum* malaria is high (Ahmed, 2007).

Nigeria accounts for a quarter of all malaria cases in Africa (WHO, 2008). In the southern part of the country, transmission occurs all year round while in the north it is more seasonal. Almost all malaria cases in the country are caused by *P. falciparum*, which is considered to be the leading cause of death worldwide in 2004, from a single infections agent (WHO, 2008). Malaria is the most common disease in Nigeria and according to the Federal Ministry of Health (FMOH, 2005), half of its population will have one or more malaria attacks annually.

Presently, there is dearth of information on the drivers of malaria transmission in Minna, North Central Nigeria (Olayemi *et al* 2009), thus the results of this study will generate data that can be applied for effective control measures of malaria in the areas of study. The aim of this study is to generate adequate information and data on the indices of malaria transmission in the study areas.

Material and methods

Study area

This study was carried out in two selected communities i.e. Tungan-Goro and Gbaiko in Minna due to their ecological set-up and the settlement of the inhabitants in Niger State, North Central Nigeria, which lies within Longitude 6°33'F and 9°37'N on a land area of 88 km² with an estimated population of 1.2 million inhabitants. The area has a tropical climate with mean annual temperature, relative humidity and rainfall of 30.20°C, 61.00% and 1,334.00 mm, respectively. The study-areas were surrounded by some streams that were few kilometres away from the habitats which served as larval breeding pools for mosquito species and other insects. The surrounding of the habitats sometimes bushy with thick and tall grasses. Mosquitoes moved easily into houses through the corridors which were permanently open at both ends of the buildings and the drainage systems were very poor. Stagnant pools were also common around the houses. Water supply remained a major problem; pond and hand-dug wells were used as sources of water supply. The climate in north-central Nigeria was that of a tropical continental region which was characterized by a relatively wide annual temperature range and a restricted rainfall. The mean annual temperature ranged from 27 to 30°C and the mean annual relative humidity was higher in the former at (76.00%) than the latter (61.00%) while the mean annual rainfall was 1,334.00 mm and the area was marked by two distinct weather seasons, i.e. rainy and dry seasons.

Ethical clearance and advocacy

Before the commencement and implementation of this study, extensive consultation was undertaken between

the researcher and the communities involved, as well as careful liaison with village, district heads as well as the parents of the children. During the pilot study, before the collection of blood samples, all stakeholders namely, health director, village heads and parents of the children were consulted for their consent. The village health workers provided participants with information regarding the reasons for the research during routine visits to the community heads. Less argument ensued following previous studies with free administration of anti malarial drugs to pupils and the ability of the researcher to communicate freely and fluently in Hausa language. It was however regrettable that some villagers as well as the parents whose wards were involved in the study were angry, alleging that their wards' samples would be used for rituals. The project was approved by the Ethical Committee of the State Ministry of Health, followed by a local approval for each study site in Niger State, Nigeria.

Mosquito collection, preservation and identification

Collections of the mosquitoes were carried out using the spread sheet Pyrethrum Spray Catches (PSC) (El-Badry and Al-Ali, 2010). The populations indoors were sampled by spreading on the floor white sheet (5m x 5m) with each edge held to the wall by masking tape. The room was sprayed with pyrethroid insecticide (Baygon) and then left for 10 minutes, with every opening shut. After the stipulated period the mosquitoes knocked down on the sheet were gathered and handpicked with a forcep into petri dishes and they were conveyed to the laboratory for identification using keys of Gullies and De Meillon (1968), Gullies and Coetzee *et al* (2000) was used for separation into sexes, physiological state, un-fed and blood-fed.

Blood samples and anopheline mosquitoes collection, processing and dissection

Blood samples and anopheline mosquitoes were collected weekly, using Pyrethrum spray catch method between 06:00 hrs-07:00 hrs, from August to October, 2011 and 2012 respectively. Mosquito collection were carried out in two sampling sites representing the general ecotype of the area. Captured mosquitoes were sorted according to the sites of collection, and were then conveyed to laboratory for further identification. The dissection of the salivary glands for sporozoites and ovary for parity was carried out according to the techniques of WHO (2002) and Service (1993).

The mosquitoes were examined for *Plasmodium* sporozoites by observing the salivary glands following the techniques of WHO (2002) and Service (1993). Briefly, the ovaries were dissected out of the abdomen at the region of 6th and 7th sclerite under a dissecting microscope using x40 and x200 objectives of Zeiss light microscope in the Department of Biology Laboratory, Federal University of Technology, Minna, and for further confirmation at the National Veterinary Research Institute Laboratory, Vom. According to Holstein (1954), these ovaries which the terminal skeins of the tracheoles were

found to be uncoiled were considered as parous while ones with coiled skein were considered nulliparous.

Parasitological analysis

Blood samples were collected from children of 0-5 years old by pricking of thumb and the blood droplet was examined, using direct thin and thick blood smear slide preparation stained with Giemsa (Mnuga *et al*, 2006), for the presence of the ring form stages of the parasites in the laboratory.

Plasmodium sporozoite infection rate

This is the number of sporozoites found in the salivary gland of dissected Anopheline mosquitoes, which was calculated by dividing the number of sporozoites positive mosquitoes by the number of mosquitoes dissected.

$$S.R. = \frac{\text{Number of sporozoites positive mosquito}}{\text{Number of dissected mosquitoes}}$$

Parous rate

This was determined by the dissection of the ovary of the collected specimen calculated by dividing the number of parous females by the number of dissected mosquitoes.

$$P.R = \frac{\text{Number of parous females mosquitoes}}{\text{Number of dissected mosquitoes}}$$

Probability of daily survival

This was estimated as the square root of the proportion of parous rate of the mosquitoes, which gives an indication as to how long the parasites will survive in the ovary/body of the female mosquitoes.

$$D.S = \sqrt{P.R}$$

Life expectancy (I.E.)

This gives an indication to the number of days the mosquitoes are expected to live to be able to transmit the sporozoites; it was calculated using the formula:

$$L.E. = 1/-\log_e p$$

Where *p* = probability of daily survival.

Results

Survey of mosquito population for Tungan-Goro and Gbaiko

The relative abundance of mosquito species within the study-areas is shown in Table 1. A total number of 742 mosquitoes were collected at the two study-areas. Four hundred and thirty mosquitoes were collected at Tungan-Goro and 312 mosquitoes collected at Gbaiko. Out of the 430 mosquitoes collected at Tungan-Goro, 232 were identified as *Anopheles* sp. while 198 were *Culex* sp. Out of the 232 *Anopheles* sp. collected at Tungan-Goro, 97 were males with 41.8% abundance while 135 were females with 58.2% abundance. Also out of the 198 *Culex* sp. from Tungan-Goro, 96 (48.5%) were males,

while 102 (51.5%) were females. At Gbaiko, 224 *Anopheles* sp. were collected, 86 (38.4%) were males, while 138 (61.1%) were females. Also out of the 88 *Culex* sp. collected at Gbaiko, 35 (39.8%) were males, while 53 (60.2%) were females. The abundances of mosquitos collected from Tungan-Goro and Gbaiko were significantly different (*p*<0.05) using *chi*-square test.

Table 1. Relative abundance of mosquito species in Tungan-Goro and Gbaiko in Minna, Nigeria.

Collection sites	Mosquito population examined	<i>Anopheles gambiae</i>		<i>Culex pipiens pipiens</i>	
		Males No. (%)	Females No. (%)	Males No. (%)	Females No. (%)
Tungan-Goro	430	97 (41.8)	135 (58.2)	96 (48.5)	102 (51.5)
Gbaiko	312	86 (38.4)	138 (61.1)	35 (39.8)	53 (60.2)
Total	742	183 (40.1)	(59.9)	(45.8)	(54.2)

χ^2 Cal (157.78) is greater than χ^2 tab (3.84) (*p*<0.05).

Sporozoites rate

A total of 365 *Anopheles gambiae* mosquitoes were dissected from a total sum of 456 that were collected, and 191 (52.3%) were positive, sporozoites were found in their salivary glands while, 174 (47.7%) were negative. For Tungan-Goro, a total number of 168 mosquitoes were dissected for the presence of sporozoites out of the 232 mosquitoes that were collected and 87 (51.8%) were positive, while 81 (48.2%) were negative. For Gbaiko, out of 224 *Anopheles* mosquitoes that were collected, 197 were dissected for the presence of sporozoites and 104 (52.8%) were positive and remaining 93 (47.2%) were negative. Using the *chi*-square test, there was a significant difference at *p*<0.05 in the sporozoite rates in the mosquitoes collected from Tungan-Goro and Gbaiko (Table 2).

Table 2. Sporozoite rates in *A. gambiae* mosquitoes in Tungan-Boro and Gbaiko in Minna, Nigeria.

Collection sites	No of mosquitoes collected	No of mosquitoes dissected	No. positive (%)	No. negative (%)
Tungan-Goro	232	168	87 (51.8)	81 (48.2)
Gbaiko	224	197	104 (52.8)	93 (47.2)
Total	456	365	191 (52.3)	174 (47.7)

χ^2 cal = 53.66, χ^2 tab = 3.84 at (*p*>0.05).

Parous and nulliparous rate determination

Parous and nulliparous rates of the *Anopheles* mosquitoes in the study-area are shown in Table 3. At Tungan-Goro 159 mosquitoes were dissected, and 103 (64.8%) were

parous while 56 (35.2%) were nulliparous. At Gbaiko, 156 mosquitoes were dissected and 108 (69.2%) were parous while 48 (30.8%) were nulliparous. Using the *chi*-square test there was a significant difference ($p < 0.05$) between the rates of parous mosquitoes in Tungan-Goro and Gbaiko.

Table 3. Parous rates of *Anopheles gambiae* mosquitoes in Tungan-Goro and Gbaiko in Minna, Nigeria.

Collection sites	Number of mosquitoes population collected	Number of mosquitoes population dissected	Number of positive parous population (%)	Number of negative parous population (%)
Tungan-Goro	232	159	103 (64.8)	56 (35.2)
Gbaiko	224	158	108 (69.2)	48 (30.8)
Grand Total	456	315	211 (67.0)	104 (33.0)

χ^2 tab = 3.84, χ^2 cal = 158.52 at ($p > 0.05$).

Table 4 shows the prevalence of malaria parasite infection among children (0-5) years at Tungan-Goro and Gbaiko in Minna, Niger State. A total of 226 children were sampled and examined from Tungan-Goro and 219 from Gbaiko. At Tungan-Goro 178 (78.8%) children were positive for malaria parasite while 48 (21.2%) were negative. At Gbaiko 137 (62.6%) children were positive while 82 (37.4%) were negative. From the 445 blood analysed for the malaria parasite, 315 were positive with malaria parasite accounting for about 70.8% prevalence of malaria infection in both study sites. The *chi*-square statistical analysis shows that there was a significant difference ($p < 0.05$) in the prevalence of malaria infection in Tungan-Goro and Gbaiko.

Table 4. Prevalence of malaria parasite infection among under five children in Tungan-Goro and Gbaiko.

Collection sites	No of children examined for malaria parasites	No of children positive (%) (Malaria Infection)	No of children negative (%) (Not infected with malaria)
Tungangoro	226	178 (78.8%)	48 (21.2%)
Gbaiko	219	137 (62.6%)	82 (37.4%)
Total	445	315 (70.8%)	130 (29.2%)

χ^2 tab = 79.06 is greater than χ^2 tab = 3.84 at ($p > 0.05$).

Discussion

This study shows high abundance of mosquito species and the prevalence of malaria parasites among children, the under five years, within the study-areas indicates active transmission.

Anopheles mosquito's relative abundance was very high though the use of some insecticides and the usage

of long lasting insecticide treated nets could reduce vector infectivity as well as vector survival rate and increase the length of the sporogonic cycle (Anonymous, 1991). Both Tungan-Goro and Gbaiko had high *Anopheles* mosquitoes which may be due to the poor environmental management of breeding sites (Angerilli, 1980) and some of the environmental practices within the study-areas which include indiscriminate disposal of containers receptacles, water storage jars, unused tyres, and abandoned cans. The *Anopheles* sp. found in these study-areas were also reported by Coluzzi *et al* (2002) as the most important vector of the malaria parasites in the sub-Saharan Africa.

Malaria parasites prevalence was high, indicating a high rate of *Plasmodium* parasitaemia among the under-five children which was in line with the high relative abundance of *Anopheles* vectors in the study-areas. This agrees with the previous work reported by Molta *et al* (2004) and Munga *et al* (2006) in Jos, north-central Nigeria and Ralph (2008) in the malaria-endemic village of Erunmu in south-west Nigeria. The sporozoites and parity rates were relatively high compare to the work and findings of Olayemi and Ande (2009) in Ilorin, which was similar to the findings of Fradin (1998) in Senegal and Ghana (Appawu *et al*, 2004). In south-west Nigeria Awolola *et al* (2003) reported the sporozoites rates for *Anopheles* mosquitoes as 5.6%, 2.9% and 1.8% respectively.

The presence and relative abundance of the adult female *Anopheles* mosquitoes as the principal vector of malaria transmission (WHO, 2002) and high the relative abundance of the *Anopheles* mosquito species within the study-areas agree with the findings of Bockarie *et al* (1994) who reported that *Anopheles* species tends to occur regularly throughout the wet and dry seasons in West Africa mostly with the peak at the rainy seasons. The high relative abundance of the mosquito species within the study-areas was also associated with the availability of suitable breeding habitats (Minakawa and Jam, 2005). The breeding sites ranged across the various types of water bodies such as temporary ground pools to large permanent water bodies within the study-areas. More so the high prevalence of malaria infection within the study-area could be attributed to the fact that the infection was already a looming endemic problem in Nigeria, including Niger State, as the surveying and sampling period coincided with the peak of raining season when mosquitoes were breeding due to the amount of rainfall from July to September. Moreover, Minna and its environs including the study-areas were relatively water-logged and poorly drained, gutters and other drainages were also routinely clogged with wastes as a result of an inefficient public waste disposal system. All these provide good breeding sites for mosquitoes which help to fuel stable and continuous malaria transmission, even beyond the peak rainy season in the months of November and December respectively.

The findings of this study indicates active transmission in the study-areas and thus explains the endemicity of malaria in Minna and its environment.

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