



Entomological and Parasitological Indices of Malaria Transmission in Minna, Niger State, North Central Nigeria

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Authors' contributions

This work was carried out in collaboration between all authors. Authors ICJO and IKO designed the study, wrote the protocol and wrote the first draft of the manuscript. Authors CAO and SCH managed the literature searches and performed the Entomological analyses and authors SSE, SP and GOU performed the Parasitological analyses. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/AIR/2015/12486

Editor(s):

- (1) Jinyong Peng, College of Pharmacy, Dalian Medical University, Dalian, China.
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Complete Peer review History: <http://www.sciencedomain.org/review-history.php?iid=695&id=31&aid=6325>

Original Research Article

Received 2nd July 2014
Accepted 2nd September 2014
Published 4th October 2014

ABSTRACT

Background: The heavy burden exerted by mosquito-borne diseases was the reason for this study to evaluate the entomological and parasitological indices of malaria disease transmission in Gidan Kwano and Mekunkele in Minna, North Central Nigeria.

Aim: The aim of this study is to determine the entomological and parasitological indices of malaria transmission of these two communities for effective control measures of malaria in the study.

Study Design: This is a survey type study conducted in two selected communities in Minna the capital of Niger State, North Central Nigeria.

Methods: Mosquitoes were sampled using Pyrethrum Spray Catches (PSC). The population

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indoors was sampled by covering the floor with a white cloth of 5m x 5m each edge being held to the wall by a masking tape. The room was spread with an insecticide a pyrethroid and then left for 10 minutes, with every opening being shut.

Results: A total of 867 mosquitoes were collected and identified: 420(48.44%) from Mekunkele and 447(51.55%) from Gidan Kwano. The collected mosquitoes were subsequently dissected for parity (egg laying status) and sporozoite rates using standard procedures. The results obtained indicates that *Anopheles* mosquitoes had a relative abundance of 542(62.51) with the females constituting 380(70.11%) and the males 162(29.88%). Gidan Kwano had the higher number of *Anopheles* mosquitoes of 287(52.95%) compared to Mekunkele with 255(47.04%). Out of the 380 females dissected, 210(55.26%) were positive for both sporozoites and parity rates, while 170(44.73%) were negative for both. Also, a total of 425 blood samples were collected and examined for malaria parasites from both locations. On the whole 277(65.20%) of the samples were positive while 148(34.80%) were negative at both locations with Mekunkele having 70.00% infection rate compared to Gidan Kwano with 60.10.% respectively. Generally, there was no significant difference in the distribution of the mosquito vectors and the malaria parasites within the study areas ($P>0.05$).

Conclusion: This study therefore will be useful as a baseline data to help in designing strategies for the control of mosquito-borne diseases in Minna and its environs.

Keywords: Malaria; anopheles; plasmodium; pyrethroid; vectors.

1. INTRODUCTION

Despite advances in treatment and prevention-over the past decades, malaria still threatens the lives of millions in tropical countries. Over the years, increasing use of control measures such as 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 vector.

Malaria is transmitted by female mosquitoes of the genus *Anopheles* because they support the sporogonic development of human malaria parasites [1]. There are over 2,500 species of *Anopheles* mosquitoes, but less than 50 are capable of transmitting malaria [1]. 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 estimated 247 million cases resulting in 881,000 deaths most of them children under the ages of five. 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 [2].

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. And it 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 [3].

Malaria transmission in these African communities is enhanced by environmental conditions such as high humidity and warmth which accelerates mosquito development. Poor quality housing also facilitates malaria transmission as the populations are continually exposed to mosquito bites. Treated nets offer protection from the mosquitoes, although bites can still occur outside the house [4].

Plasmodium falciparum is responsible for most malaria related deaths worldwide and is the predominant *Plasmodium* species in Sub-Saharan Africa. Transmission intensity and population at risk vary substantially between and within countries [5]. Of the 2.4 billion people at risk of *falciparum* malaria, 70% live in areas of 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 [6].

Nigeria accounts for a quarter of all malaria cases in Africa [7]. It is endemic throughout Nigeria with a high percentage of the population at risk. 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 *Plasmodium falciparum*, considered to be the leading cause of death worldwide in 2004, from a single infections agent [2]. Malaria is the most common disease in Nigeria and according to the Federal Ministry of Health [8], half of its population will have one or more malaria attacks annually. It also reported that malaria accounts for 25 percent of infant mortality and 30 percent of childhood mortality in Nigeria [7].

The importance of detailed knowledge of local determinants of malaria is of primary importance in the development of area-specific control interventions that will effectively lead to the control of the disease. Presently, there is a little information on these drivers of malaria transmission in Minna, North Central Nigeria [9], thus the aim of this study is to determine the entomological and parasitological indices of malaria transmission of this two communities for effective control measures of malaria in the study.

2. MATERIALS AND METHODS

2.1 Study Area

This study was carried out in two selected communities in Minna, Niger State in the North Central Nigeria (Fig. 1) which lies within longitude 6°33'F and 9°37'N on a land area of 88km² and having an estimated population of 1.2 million inhabitants (2006 Population Census). The area has a tropical climate with mean annual temperature, relative humidity and rainfall of 30.20°C, 61.00% and 1334.00mm, respectively. The study areas are surrounded with some streams that are few kilometres away from their habitats and that served as larval breeding pools for mosquito species and other insects. The surrounding of habitation sometimes remains permanently bushy with thick and tall grasses. Mosquitoes move easily into houses through the corridors which are permanently open at both ends of their buildings and the drainage systems are very poor. Stagnant pools are also common around the houses. Water supply also remains a major problem, while pond and hand dug wells are used as a source of water supply. The climate in North Central Nigeria is that of a tropical Continental region which is characterized

by a relatively wide annual temperature range and a restricted rainfall. The mean annual temperature range from 27 to 30°C and the mean annual relative humidity is higher in the former at (76.00%) than the latter (61.00%), while the mean annual rainfall ranges from 1,334.00mm and the area is marked by two distinct weather seasons. i.e. rainy and dry seasons. The rainy seasons usually starts in May and lasts till October with June and August as the months with peak amount of rainfalls. The dry season extending from December to March which is completely devoid of rains and characterized by harmattan with dust laden cold winds from the North-east wind.

2.2 Ethical Considerations

All work was performed according to the guidelines for human experimentations in clinical research stated by the Federal Ministry of Health of Nigeria. This study was approved by the ethical committee of General Hospital Minna, Nigeria. Parents of children gave oral informed consent.

2.3 Mosquito Collection, Preservation and Identification

Collection of mosquito was carried out using Pyrethrum Spray Catches [10,11]. The population indoors was sampled by covering the floor with a white sheet of 5m x 5m each edge held to the wall by a masking tape. The room was spread with an insecticide a pyrethroid and then left for 10 minutes, with every opening being shut. After the period the mosquitoes found on the sheet were gathered and handpicked with a forceps into petri dishes and they were conveyed to the laboratory for identification using keys of Gullies and De Mellon [12] with Gullies and Coetzee et al. [13] into sexed separated by physiological state, unfed and blood fed.

2.4 Specimen Collection, Processing and Dissection

Peripheral blood was collected from the right thumb of children under five years. *Anopheles* mosquitoes were collected weekly using Pyrethrum spray Method between 06:00hrs – 07:00hrs from August to October, 2011 and 2012 respectively Mosquito collection were carried out on two sampling sites representing the general ecotype of the area. Captured mosquitoes were sorted according to the sites of collection, and

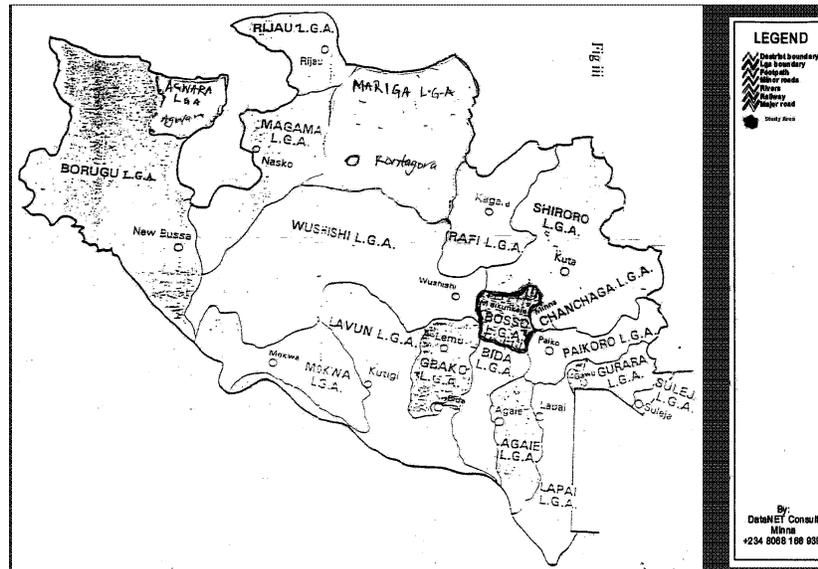


Fig. 1. Map of Niger state showing Minna (Bosso and Chanchaga LGAs) metropolis

were then conveyed to laboratory for further identification using the keys of Gilles and De Meillon [12]. Also Dissection of the salivary glands for sporozoites and ovary for parity was carried out according to the techniques of WHO [14] and Service [15].

The adult sampled mosquitoes were examined for *Plasmodium* sporozoites by investigating the salivary glands following the techniques of WHO (2002) and Service (1993) the ovaries were dissected out of the abdomen at the region of 6th and 7th under a dissecting microscope using x40 and x200 objectives of Zeiss light microscope in the school Laboratory and at the National Veterinary Research Institute laboratory in Vom, using the method of Holstein [16], 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.

2.5 Parasitological Analysis

Blood samples that were collected from children of 0 – 5 years old by pricking gently of their thumb and the blood droplet was examined using a direct thin and thick blood smear preparation stained with Giemsa as demonstrated by Mnuga et al. [17] for the presence of the ring form stages of the parasites in the blood of the individuals in the laboratory.

2.6 Plasmodium Sporozoite Infection Rate

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

$$S.R. = \frac{\text{Number of sporozoite s positive mosquitoes}}{\text{Number of dissected mosquitoes}}$$

2.7 Parous Rate

This was determined by the dissection of the ovary of the collected specimen and was calculated by dividing the number of parous females by the number of dissected mosquitoes. This will show the cycle of oviposition.

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

2.8 Scope and Limitation

The study was restricted to two selected communities in Minna Niger State and these selected communities are Mekunkele and GidanKwano respectively and among 0-5 years of human populations while the vector collection was in-door.

3. RESULTS

The relative abundance of mosquito species within the study areas, with 867 mosquitoes collected at both locations are shown in Table 1. A total of 420 mosquitoes were collected at Mekunkele comprising 255 *Anopheles gambiae* with 78 (30.60%) males and 177 (30.20%) females while 165 were *Culex pipiens pipiens* with 65 (39.40%) males and 100 (60.6%) females. At Gidan Kwano a total of 447 mosquitoes species were collected, of these 287 were *Anopheles gambiae* with 84(29.3%) males and 203 (70.7%) females. And 160 were *Culex* species with 108 (67.5%) males and 52 (32.5%) females. Out of 542 *Anopheles gambiae* females, 380 were dissected for both parity and sporozoite rates respectively.

Positive rate of sporozoite in *Anopheles gambiae* in the study areas showed that of 177 mosquitoes dissected 95(53%) were positive for the sporozoites while 82 (46%) were negative out of the total number dissected at Mekunkele. At GidanKwano out of the 203 mosquitoes dissected for sporozoites 115 (56%) were positive while 88 (43.3%) were negative. Chi-square analysis showed that there is no

significant difference ($P>0.05$) in the sporozoite infection rates among the individual mosquito species in the study. Therefore malaria parasites transmission within the study areas i.e. Mekunkele and Gidan Kwano in Minna were stable as shown in Table (Table 2).

Parous and nulliparous rates of the *Anopheles gambiae* is 53% at Mekunkele out of 177 mosquitoes dissected as 56% mosquitoes were parous out of the 203 dissected at GidanKwano. Chi-square analysis has also shown that there is a significant difference in the parous rate of mosquitoes infected and those nulliparous as shown in table (Table 3).

Table 4 above showed the prevalence of malaria parasites infection among the under five (0-5) years of children population at Mekunkele and GidanKwano in Minna Niger State. Of the 425 children examined for the malaria parasites at both locations 152 (70%) were infected with *P. falciparum*. At Maikunkele 152 (70.00%) were infected out of 217 examined while at GidanKwano out of 208 children 125 (60.10%) were infected. There was no significant difference ($p>0.05$) in the malaria infection rates between the two areas.

Table 1. Relative abundance of Mosquito species at mekunkele and Gidan Kwano in Minna, Niger State, North Central Nigeria

Site	No. of mosquitoes collected	<i>Anopheles gambiae</i>		<i>Culex pipiens pipiens</i>	
		Males No. (%)	Females No. (%)	Males No. (%)	Females No. (%)
Mekunkele	420	78(30.6%)	177(30.2%)	65(39.4%)	100(60.6%)
GidanKwano	447	84(29.3%)	203(70.7%)	108(67.5%)	52(32.5%)
TOTAL	867	162(29.9%)	380(70.1%)	173 (53.2%)	152 (46.8)

Table 2. Sporozoites infection rate of *Anopheles gambiae* at Mekunkele and Gidan Kwano in Minna, Niger State, North Central Nigeria

Collection sites	No. of mosquitoes collected	No. dissected	No. positive (%)	No. negative (%)
Mekunkele	255	177	95(53%)	82(46%)
GidanKwano	287	203	115(56.7%)	88(43.3%)
TOTAL	542	380	210(55.3%)	170(44.7%)

Table 3. Parous rate of *Anopheles gambiae* at Mekunkele and Gidan Kwano in Minna, Niger State, North Central Nigeria

Collection sites	No. of mosquitoes collected	No. dissected	No. positive (%)	No. negative (%)
Mekunkele	255	177	95(53%)	82(46%)
GidanKwano	287	203	115(56.7%)	88(43.3%)
TOTAL	542	380	210(55.3%)	170(44.7%)

Table 4. Prevalence of malaria parasite among under five children at Mekunkele and Gidan Kwano in Minna, Niger State, North Central Nigeria

Collection sites	No examined	No positive (%)	No negative (%)
Mekunkele	217	152(70%)	65(29.9%)
GidanKwano	208	125(60.1%)	83(39.9%)
TOTAL	425	277(65.2%)	148(34.8%)

4. DISCUSSION

This study showed high abundance of mosquito species and the prevalence of malaria parasites among the under five children within the study areas as indicators of malaria transmission.

Anopheles mosquitos' relative abundance was very high though the use of some insecticides and usage of long lasting insecticide treated nets can reduce vector infectivity as well as vector survival rate and the length of the sporogonic cycle [18]. Both Gidan Kwano and Mekunkele had high Anopheles mosquitoes which may be due to the availability of temporary breeding sites as reported by Angerilli [19] and some of the environmental practices within the study areas which include disposing of containers, receptacles, water storage jars, unused tyres, abandoned cans etc., also the Anopheles species found in this study areas were also reported by Coluzzi et al. [20] which is the most important vector of the malaria parasites in the Sub-Saharan Africa, in connection with certain climatic factors most especially the annual precipitation appears to influence the range and the relative abundance of the mosquito species.

Malaria parasites prevalence was high indicating a high rate of Plasmodium parasitaemia among the under five children which is in line with the high relative abundance Anopheles vectors sampled within the study areas which agrees with the previous work reported by Molta et al. [21], [22] in Jos North Central Nigeria and Ralph [23] in the malaria endemic village of Erunmu in southwest Nigeria. For the sporozoites and parity rates determination of 55% is relatively high compare to the work and findings of Olayemi and Ande [24] in Ilorin, which was also similar to the findings of Fradin et al. [25] in Senegal with 25% prevalence of sporozoites and parity rates determination and higher than the 7.1% reported in Ghana by Appawu et al. [26], also in south west Nigeria by Awolola et al. [27] that reported the prevalence of sporozoites rates of Anopheles mosquitoes as 5.6%, 2.9% and 1.8% respectively. However, findings in this study showed that all parous Anopheles mosquitoes were infected, since they were all carrying

sporozoites unlike in other studies in Senegal and Ghana and even Lagos State in South West Nigeria [25,26,27]. It showed that Anopheles mosquitoes in selected in the study areas are effective vectors of malaria transmission.

The results obtained from the parasitological examination of blood samples of the under five children is in line with the presence and relative abundance of the adult female Anopheles mosquitoes as the principal vector of malaria transmission [14], the relative abundance of the Anopheles mosquito species within the study areas also agrees with the findings of Bockarie et al. [28] 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 which is in line with the period the study was carried out. The relative abundance of the mosquito species within the study areas was also associated with the availability of suitable breeding habitats within the locations as described by Minakawa et al. [29]. The breeding sites ranges across the various types of water bodies such as temporary ground pools to large permanent water bodies found within the study areas. More so the high rate of malaria infection within the study area could be attributed to the fact that the infection is already a looming endemic problem in Nigeria, including Niger State as the sampling and surveying period coincided with the peak of raining season when mosquitoes are breeding due to the amount of rainfall from July to September. Moreover Minna and its environs including the study areas are relatively water logged and poorly drained areas, gutters and other drainages are 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.

5. CONCLUSION

The findings of this study indicates that both the entomological and parasitological indices of malaria transmission which includes the

sporozoites found in the salivary glands of the female Anopheles as well as their parous nature and the Plasmodium parasites found in the blood samples of the under five children are well-established in the study areas, thus explaining the endemicity of malaria in Minna and its environment.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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Peer-review history:

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