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Research Article

Investigation on the Infectivity Rate of *Plasmodium* Parasites and Prevalence of Mosquitoes Genera in Katsina-Ala Metropolis, Benue State, Nigeria

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ABSTRACT

Malaria remains the leading cause of mortality and morbidity in Africa. It is increasing throughout Katsina-Ala, Benue State, Nigeria and the world as a whole, due to the bite of the female anopheles mosquito. This study was carried out to identify the genera of mosquito and to determine the infectivity rate of plasmodium parasites among people in Katsina-Ala Metropolis, Benue State, Nigeria. Adult Mosquitoes were collected and morphologically identified exclusively. Blood samples were collected from 318 individuals and the presence of plasmodium parasites was examined on the microscope through Field stains (A and B) method. Out of the 318 samples collected, 253 were infected with plasmodium parasites with highest prevalence of infection of (80.21%) which was recorded among the female and the prevalence of infection of (79.01%) was recorded among the male. Age group 56-65 years recorded highest prevalence of infection of 100% while least infection (70.71%) was recorded among individuals within 5 - 15 years age group. The Genus of mosquitoes identified in the study was *Anopheles*, *Culex* and *Aedes*. Anopheles were found to be the most abundant with 98 mosquitoes (39.68%) and with the highest female mosquito of 66, suggesting that anopheles mosquitoes were the primary vectors responsible for transmitting malaria, a serious and potentially life-threatening disease. It can be concluded that there was high prevalence of malaria infection in the study area with high abundance of female anopheles mosquitoes. Efforts should be done on community-based malaria awareness and education campaigns for malaria prevention and control.

Keywords: Investigation; Infectivity rate; Mosquitoes genera; *Plasmodium* parasites; Prevalence

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INTRODUCTION

Mosquitoes are insects belonging to the order Diptera, the true flies. They are slender and relatively small insects, usually measuring about 3– 6 mm in length. Some species, however, can be as small as 2mm while others may be as long as 19 mm. The long antennae have numerous whorls of hair, short in the female and long and bushy in the male. In most species of mosquitoes, the mouth parts of the female are long, adapted for piercing and for sucking blood. The male, which feeds on nectar and water, has rudimentary mouth parts (Service, 2012; Abubakar, 2014).

In the broad sense, vectors encompass any organism involved in the transmission of an infectious agent. More specifically, in medical and veterinary entomology, vectors designate any haematophagous arthropod which actively transmits an infectious pathogen from an infected host to a new host (Duvallet *et al.*, 2018). In a given zoological group, vector species are ordinarily outnumbered by other non-vector species. For instance, among the 540 species of mosquito in the subfamily of Anophelinae, about 60 species are recognised as vectors of Plasmodium, the agent of malaria (Counihan, 2019). Identification of arthropod species, both vectors and non-vectors, is a

core capacity in the field of medical and veterinary entomology. Accurate identification of a species involved in transmitting a pathogen is essential for a proper understanding of the mechanisms that govern any biological system. Knowing which arthropod species transmit vector-borne diseases is also vital to providing species-specific focused control programmes and to correctly identifying disease risk and exposure (Failloux *et al*., 2017).

Mosquito-borne diseases cause suffering and hundreds of thousands of deaths every year. Malaria remains a leading cause of mortality and morbidity in Africa, killing over 600,000 people annually (WHO, 2021) and arboviral diseases transmitted by Aedes mosquitoes, like dengue, chikungunya and Zika have placed more than half of the world's population at risk (Wilder-Smith *et al*., 2017). Vector control and in particular the use of insecticides in domestic environments (insecticide-treated bed nets and indoor residual spraying) and mosquito breeding sites, remains the most effective tool in averting mosquito-borne infections (Bahatt *et al*., 2015). However, increasing insecticide resistance (Ranson and Lissenden, 2016; Dusfour *et al*., 2019) intensifying the search for new vector control tools (Achee *et al*., 2019; Quinn *et al.,* 2020) and it becomes critical to have methods for evaluating the efficacy of mosquito control interventions. Epidemiological studies are considered the gold standard in evaluating the impact of vector control on disease transmission, but they are logistically and financially challenging. An alternative faster and cheaper approach could be the collection of robust entomological data that can directly reflect the risk of disease transmission.

Malaria is caused by a protozoan parasite of the genus *Plasmodium*, is one of the most important and devastating infectious diseases, particularly, in developing countries (Mark, 1998). Malaria is a major public health problem in tropical and subtropical regions of the world, especially among pregnant women because of the associated maternal and prenatal morbidity and mortality (Ordinioha, 2012)). Malaria transmission in Nigeria is holo - endemic and more than 90% of the population lives in areas with stable malaria. It is one of the leading causes of morbidity and mortality among the population, especially among children under five. Malaria has continued to present a considerable risk to most households in Nigeria and is often stated as one of the top ten health problems. Estimate shows that malaria accounts for 50% of outpatient consultations and 15% to 31% of hospital admission and 23% deaths among children under five (Global Net Work, 2011).

The disease is transmitted from one person to another through the bites of infected female *anopheles* mosquito vectors during blood meal (Abbey, 2010). Over 40% of the global population lives in areas where malaria transmission occurs, it is estimated that 300 – 500 million cases of malaria occurs each year resulting to over two million deaths (WHO, 2011). The burden of malaria is largely borne by Africa; Nigeria accounted for the highest proportion of malaria cases globally with (27%), followed by the Democratic Republic of the Congo with (10%), India with (6%), and Mozambique with (4%) (WHO, 2017). Despite the amount of resources spent in the control of malaria for past many years 57% of African population lives in areas at ricks of malaria, but there is decrease in malaria infection from 2000 to 2010 and for now more than 100 million people lives in areas where malaria transmission is low, there is decrease in the prevalence of malaria infection in children from 40 out of the 44 countries in Africa from 2000 to 2010.There is success in the malaria control programmes in some African countries such as South African, Ethiopia e.t.c. these countries have joined other African countries where malaria can be eradicated. Countries of the world have increased the amount of resources they spent in malaria control programmes from 100 million dollars to 200 billion dollars. But there is need to increase effort in malaria control programmes especially distribution of free ITNs (WHO, 2014).

The World Malaria Report of 2022 by WHO stated that despite the continued impact of COVID-19, Malaria cases and deaths remained stable in 2021. The 2022 edition of the report finds that, despite disruptions to prevention, diagnostic and treatment services during the pandemic, countries around the world have largely held the line against further setbacks to malaria control. There were estimated 619,000 malaria deaths globally in 2021 compared to 625,000 in the first year of the pandemic in 2019, before the pandemic struck, the number of deaths stood at 568,000. Malaria cases continued to rise between 2020 and 2021 but at a slower rate than from2019 to 2020. The global tally of malaria cases reached 247 million in 2021, compared to 245 million in 2020 and 232 million in 2019 (WHO, 2022).

Malaria is made up of types depending on the plasmodium involves.Five species are known to infect man name*ly: P. falciparum* of malignant tertian malaria, *P. vivax* of benign tertian malaria, *P. malariae* of quartian malaria, *P. ovale* of benign tertian malaria and *P. knwelensi*. The life cycle of malaria parasite involves the cycle in the blood of man and cycle in mosquito (Owusu-Ofuri *et al.*, 2013). Different approaches to mosquito identification are available: morphological, molecular (PCR and nucleic acids sequencing), proteomics tools, isozyme analysis, etc. (Fontenille_*et*

al., 2017; Nayduch *et al*., 2009). However, for historical and technical reasons, morphological identification is still the reference method for both research purposes and operational surveillance as it requires little technical equipment, is easy to implement in the field and is inexpensive even when large numbers of individuals need to be identified. The method has three principal limitations, the first being that it relies on expert entomologists performing the identification, especially when many species are present in the collection area. The second limitation resides in the level of preservation of the morphological characters used in the sample handling process. The third concerns species complexes and a few morphologically similar species where identification should be based on more than one developmental stage, which is not always accessible (Leung, 2000).

The rapid growth and development of mosquitoes as vector that serves as a leading cause of malaria and so many diseases has become very common and is increasing in an uncontrolled way throughout Katsina-Ala Benue State, Nigeria and world as a whole, due to the bite of the female anopheles mosquito which carries the plasmodium. In an attempt to eradicate this deadly disease, a massive response needs to be mounted by the government to enlighten the public about the prevalence of malaria. Also provide remedy for treatment, and to reduce the multiplication of mosquitoes taken into consideration the control majors (Hagedorn *et al.*, 2010).

MATERIALS AND METHODS

Study Area

Katsina-Ala is a Local Government Area of Benue State, Nigeria; with coordinates 7°10′0″N 9°17′0″E.It headquarter is in the town of Katsina-Ala where the A344 highway starts. Benue typically receives about 135.2 millimeters (5.32 inches) of precipitation and has 160.01 rainy days (43.84% of the time) annually. Katsina-Ala LGA has an area of 2,402 km2 (927 sq mi) and a population of 224,718 at the 2006 census. The town center is the location of one of the oldest schools in Nigeria, Government College Katsina-Ala, founded in 1914. The postal code of the area is 980 (NIPOST, 2012). The community, which lies on the banks of the Katsina Ala River, a major tributary of the Benue River, is mainly occupied by Etulo, Tiv and Hausas. The major language of communication in Katsina Ala is in Tiv. It contained water bodies like streams lakes which provide a favourable condition for the reproduction of mosquitoes. It's also the location of an important archaeological site where artifacts of the Nok culture have been found (Thurstan, 1995).

Materials

Light microscopes, dissecting microscopes, microscopic slide, blood lancets, insecticides, syringes and needles, cotton wool, spirit, EDTA tubes, field stains A and B, immersion oil, insect catching nets.

Sample Collection and Identification

Adult Mosquitoes were collected from various parts of Katsina-Ala using indoor insecticidal spray in 3 different sites. All identifications of the collected adult mosquitoes were exclusively morphology based. 318 blood samples were collected and it were examined forthe presence of plasmodium parasites on the microscope through staining techniques (Field stains (A and B) for the identification of plasmodium parasites (Rattanarithikul et al., 2007).

Procedure for Staining

Three hundred and eighteen (318) blood samples were collected from participants using syringe and needle, the finger was cleaned with cotton wool soaked in 70% ethanol to disinfect the finger and it was punctured using needle and small drop of blood was placed in the centre of the cleaned labelled slide. Through the use of the corner of another slide or an applicator stick, the drop was spread in a circular pattern until it was in size of a dime (1-5cm2) and allowed to air dry thoroughly by laying it flat on stand staining rack. A solution of field stain "A" was applied on the smear and rinsed it with water. Another solution of field stain "B" was also applied and rinsed with water. The slide was then placed on staining rack and allowed to air dry thoroughly. The smear was fixed by applying a drop of immersion oil and made ready for microscopic examination. The slide was examined with the use of light microscope using x100 0bjective lens.

Ethical consideration

A letter of introduction was obtained from the Department of Biological Sciences, Federal University Wukari to Director of Health Katsina Ala Local Government and an ethical clearance was obtained from the Director of Health Katsina Ala Local Government. The purpose and procedures of the study were explained to the participants and their consents were obtained before participation.

Data Analysis

The data obtained from this research work were analysed using SPSS version 20. Significant level of differences between the values of species of mosquitoes and infections were determined at 5% confident interval.

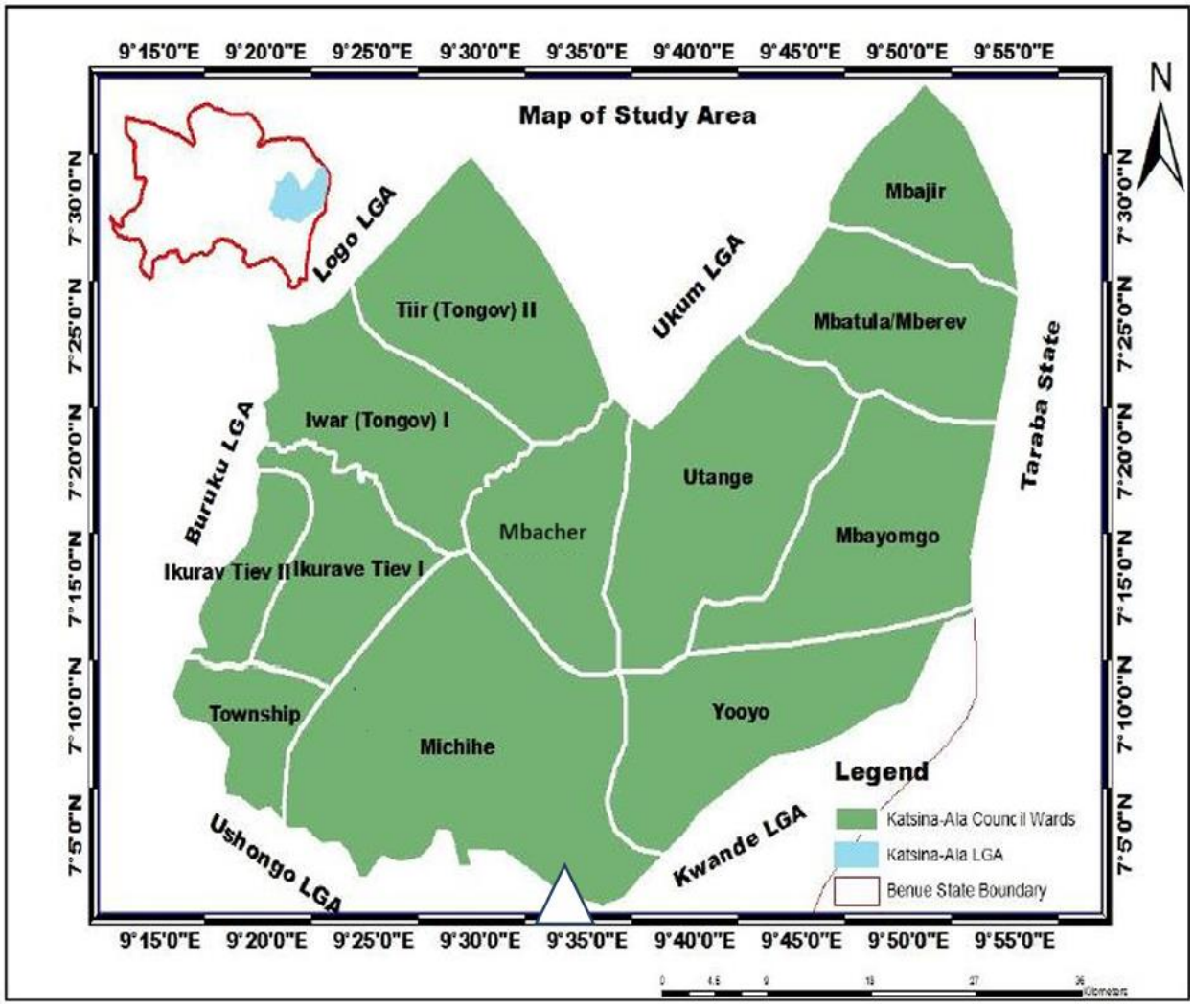

Figure1; Mapof Katsina-Ala showing studyareas (source: www.researchgate.net)

RESULTS

Prevalence of Plasmodium Parasites Infection according to Gender

Prevalence of Plasmodium parasite infection according to gender is shown in Table 1: Out of the 318 sample of blood collected 253 were positive with highest prevalence of infection of (80.21%) which was recorded among the female and the prevalence of infection of (79.01%) was recorded among the male. Chi-Square test showed a significant association between the rate of infection and gender (X^2 = 13.3, 1df =3.841; p=0.05).

Prevalence of plasmodium parasites infection according to age

Prevalence of plasmodium parasites infection according to age is shown in Table 2. Out of the 318 samples collected 253 were infected with prevalence of infection of (80.06%). The highest prevalence of infection of 100% was recorded among the age group 56-65 years follow by age group 36 - 45 years with prevalence of infection of (85.74%). However, age group 5 - 15 years recorded the least infection of (70.71%). Chi-square test showed significant association between the rate of infection and age. (X^2= 14.05, 3df =11.071, p=0.05).

Prevalence of mosquito according genera

Incidence of mosquito according genera is shown in Table 3. The genera of mosquitoes found in the study Area were Anopheles mosquito, Culex mosquito and Aedes mosquito. Anopheles mosquito had the highest prevalence of 98(39.68%), followed by Culex mosquito with prevalence of 80(32.39%), Aedes mosquito had the least prevalence of 69(27.93%).

Prevalence of mosquito's genera according to gender

Incidence of mosquito's genera according to gender is shown in Table 4. Out of 247 mosquitoes identify 161 were female and 86 were male, Anopheles mosquito had the highest number of female mosquitoes of 66, followed by Culex mosquito with 52, and Aedes mosquitoes with least female of 43.

Table 1: Prevalence of Plasmodium Parasite Infection according to Gender

Gender	No. Examined	No. Infected	Percentage Infected (%)
Male	181	143	79.01
Female	137	110	80.29
Total	**318**	**253**	**79.56**

X^2 1df =3.841, X^2cal = $(0-E)^2/E$=13.3, P= 0.05

Table 2: Prevalence of *Plasmodium* Parasite Infection according to Age

Age (Years)	No. Examined	No. Infected	Percentage Infected (%)
5-15	69	55	79.71
16-25	126	102	80.92
26-35	82	60	73.17
36-45	21	18	85.74
46-55	13	11	84.62
56-65	7	7	100
Total	**318**	**253**	**79.56**

X^2 1df =3.841, X^2cal = $(0-E)^2/E$=13.3, P= 0.05

Table 3: Abundance of Mosquitoes Genera Found in the study Area

Genera	Number Found	Percentage Found (%)
Anopeheles	98	39.68
Culex	80	32.39
Aedes	69	27.93
Total	**247**	**100**

Table 4: Genera of Mosquitoes Found in the study Area according to gender

Genera	***Anopheles***	***Culex***	***Aedes***	**Total**
Male	32	28	26	**86**
Female	66	52	43	**161**
Total	**98**	**80**	**69**	**247**

DISCUSSION

Out of the 318blood sample collected 253 were infected with highest prevalence of infection of (80.21%) which was recorded among the female and the prevalence of infection of (79.01%) was recorded among the male. The findings agrees with Obimakinde and Simon-Oke (2017) who recorded prevalence of malaria infection of (78.7%) among the patients attending the health centre of the Federal University of Technology, Akure, Nigeria. The difference in prevalence among the sexes could be as a result of the Genotyping in the patients. People with genotype AA are highly susceptible to malaria infection compared to people with genotype AS or SS. The elevated occurrence of malaria infection in the region under investigation may be linked to various factors, including unregulated waste disposal practices, inadequate drainage infrastructure, neglected wells, and dense vegetation, all of which create conducive environments for female mosquitoes to breed and thrive (Okell *et al*., 2012).

The highest prevalence of infection of 100% was recorded among the age group 56-65 years followed by age group 36 - 45 years (85.74%). However, age group 5 - 15 years recorded the least infection of (70.71%). The high prevalence recorded for individuals between the 56–65 age groups may be attributed to the weakened immune system in older person, making them more susceptible to malaria infection. Older individuals may engage in outdoor activities such as farming, fishing, or other occupations that increase their exposure to mosquito bites, especially in endemic areas where malaria transmission is high. Though all the age groups were susceptible to the infection, differences in habits could be as a result of the different prevalence values within the different age group. The low prevalence in the younger age groups suggested that they have acquired immunity which they might have developed due to previous exposure to the infection (Doolan *et al.*, 2009). Generally, poor housing conditions, lack of access to mosquito control measures like bed nets, and proximity to mosquito breeding sites could increase the risk of malaria infection among individuals (Graves *et al*., 2011; Oyekale, 2015).

Other researchers have highlighted the prevalence of malaria infection among different age groups. A study conducted by Fana *et al*. (2015) showed that pregnant

women within the 14 – 20 years age group had the highest prevalence (51.6%). This finding contrasts the current study. Umaru and Uyaiabasi (2015) observed higher prevalence among patients in the 5-15 years age category (19.3%) which may be attributed to children in this age category leaving the comfort of their homes for the first time for boarding school or other purposes hence are away from direct parental care and supervision.

The genera of mosquitoes identified in this study were anopheles, culex and aedes. The three mosquito genera indicate diversity of mosquito species present in the area under investigation. Among these genera, Anopheles was found to be the most predominant, with a total abundance of 98(39.68%) mosquitoes. A study conducted by Afolabi *et al*., (2019) identified 5 Aedes species, 6 Culex species, and a species of Anopheles and Toxorhynchites. Culex has the highest abundance (2151) and Toxorhynchites had the lowest (23). Factors such as seasonal fluctuations, habitat preferences, and environmental conditions can influence mosquito abundance and species composition. Incidence of mosquito's genera according to gender is shows that out of 247 mosquitoes identify, 161 were female and 86 were male, Anopheles mosquito had the highest number of female mosquitoes of 66. The high abundance of female Anopheles mosquitoes in the study area, suggests that Anopheles mosquitoes are the primary vectors responsible for transmitting malaria, a serious and potentially life-threatening disease.

CONCLUSION

Malaria infection remains a significant public health challenge in many regions of the country. The findings of this study provided several keys information into the prevalence, distribution, and factors influencing malaria infection. This research has revealed that there was high prevalence of malaria infection in the study area. The study showed that females' patients were the most predominant in terms of gender and older individuals within the age group (56-65) are most susceptible to malaria infection. Anopheles was identified as the most predominant mosquito genus indicating that they are the primary vectors responsible for transmitting malaria, a serious and potentially life-threatening disease.

Conflict of Interest

There were no any conflicts of interest between the authors from beginning of the study to the end. Everything went well as design and agrees on the proposal.

Author Contributions:

Conceptualization, M.K. H.F.A. and O.S.Y.; methodology, M.K.; validation, M.K. and H.F.A.; formal analysis, M.K. and H.F.A.; investigation, H.F.A. and O.S.Y.; resources, M.K.; O.S.Y. and H.F.A.; data collection, M.K. and H.F.A.; writing original draft preparation, M.K.; writing review and editing, M.K. O.S.Y. and H.F.A.

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