

**SURVEY OF MEDICALLY IMPORTANT INSECTS IN SOKOTO
METROPOLIS**

BY

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CERTIFICATION

This research project titled "Survey of Medically Important Insects in Sokoto Metropolis" by HASSAN MUSA IBRAHIM with Adm. No: 2010302021 meets the regulation governing the award of Bachelor of Science (B. Sc.) Degree in BIOLOGY of the Usmanu Danfodiyo University Sokoto, and it is approved for its contribution to scientific knowledge and literary presentation.

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DEDICATION

I wholeheartedly dedicate this research project to my beloved and dedicated Father, Alh. Musa Ibrahim and my Mother Haj. Hauwa'u (Kulu) Musa spiritually and financially.

I also dedicated to late Zainabu, late Usamatu and late twin sister Halimatus-sadiya (Hussaina), may their souls rest in Jannatul-firdasi Amin!

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ABSTRACT

Diversity and distribution of medically important insect species within Sokoto Metropolis. This was investigated in a semi-arid region of the Sudan savanna characterized by seasonal rainfall and human-driven environmental modifications that favor vector proliferation. A descriptive cross-sectional design was employed, with sampling sites purposively selected based on ecological characteristics such as sanitation level, proximity to water bodies, and vegetation cover. Multiple vector surveillance techniques including CDC light traps, light traps with spray sheets, sticky interceptors, baited traps, sweep nets, and sticky papers were deployed to capture a wide range of insects across selected urban and peri-urban locations. Specimens were identified morphologically using established taxonomic keys, and data were analyzed using descriptive statistics and biodiversity indices. Across all methods, mosquitoes constituted the dominant medically important vectors. From CDC light traps alone, 60 mosquitoes belonging to *Anopheles*, *Aedes*, and *Culex* genera were recorded, with *Culex* species accounting for 70% of the total catch. Additional trapping methods revealed similar trends, with *Culex* consistently dominant, while *Anopheles* appeared in smaller numbers and *Aedes* was largely absent from nocturnal traps. Non-mosquito vectors collected included houseflies (*Musca domestica*, 71.4%) and lice (*Pediculus* spp., 28.6%), indicating the persistence of mechanical vectors associated with poor sanitation. Overall, the results highlight significant vector presence across Sokoto Metropolis, with *Culex* species being the most widespread, suggesting environmental conditions that favor their breeding. The presence of *Anopheles* and filth flies underscores ongoing risks for malaria and hygiene-related diseases. Strengthened vector surveillance, improved environmental sanitation, and targeted control interventions are recommended to mitigate vector-borne disease transmission in the area.

CHAPTER ONE

1.0

INTRODUCTION

1.1 Background of the Study

Insects constitute the most diverse group of organisms on Earth, playing critical roles in ecological systems, agriculture, and public health. Among them, a significant number are considered medically important due to their capacity to act as vectors for pathogens, cause allergic reactions, or directly inflict injury on humans. These insects, which include mosquitoes, houseflies, sandflies, tsetse flies, fleas, lice, and bedbugs, are responsible for the transmission of a wide range of diseases such as malaria, dengue fever, leishmaniasis, trypanosomiasis, typhoid fever, and several others (World Health Organization (WHO, 2020). In tropical and subtropical regions, including many parts of Nigeria, the public health burden of these vector-borne diseases is substantial, particularly where poor environmental sanitation and limited healthcare infrastructure prevail (Okwa, 2009; Adeleke *et al.*, 2010).

Sokoto Metropolis, located in northwestern Nigeria, is an area characterized by a semi-arid climate, seasonal rainfall, and rapid urban expansion. These conditions, combined with socio-economic factors such as population growth, inadequate waste management, and the proliferation of informal settlements, create a conducive

environment for the proliferation of medically important insects (Nwachukwu and Umeokeke, 2012). Stagnant water bodies, accumulated refuse, animal dung, and open drainage systems commonly found in parts of the metropolis serve as breeding and resting sites for many insect vectors (Adebote *et al.*, 2008; WHO, 2017). Consequently, the risk of vector-borne and insect-related diseases remains a persistent public health challenge in the region (Ekanem *et al.*, 2018).

Despite the obvious risks associated with insect vectors in Sokoto, there is limited recent empirical data on the diversity, distribution, and abundance of medically important insects within the metropolis. A comprehensive understanding of the insect fauna and their potential health impacts is essential for designing effective vector control strategies and public health interventions. Such knowledge is also crucial for guiding policymakers, environmental health officers, and community stakeholders in making informed decisions regarding disease prevention and control (Becker *et al.*, 2010; Oduola *et al.*, 2016).

This study, therefore, aims to conduct a systematic survey of medically important insects across selected locations in Sokoto Metropolis. The survey seeks to identify the species present, assess their relative abundance, and determine the environmental conditions that favor their proliferation. By generating baseline data on medically

significant insect populations, this research will contribute to the body of knowledge needed for developing targeted insect vector management programs and enhancing the overall public health framework in Sokoto and its environs.

1.2 Statement of the Research Problem

Medically important insects such as mosquitoes, houseflies, sandflies, and tsetse flies pose a significant threat to public health due to their role in the transmission of infectious diseases including malaria, typhoid fever, leishmaniasis, and sleeping sickness (World Health Organization [WHO], 2020; Service, 2012). In Nigeria, and particularly in Sokoto Metropolis, the incidence of vector-borne diseases remains high, contributing to increased morbidity and mortality, especially among children and other vulnerable populations (Okwa, 2009; Ekanem *et al.*, 2018).

Urbanization, poor sanitation, open drainages, and inadequate waste management in Sokoto create conducive breeding environments for insect vectors (Adebote *et al.*, 2008; Nwachukwu and Umeokeke, 2012). Despite this, routine surveillance and control measures are either weak or inconsistently implemented. Most control efforts are often reactive, triggered by disease outbreaks rather than guided by continuous entomological monitoring and evidence-based planning (Oduola *et al.*, 2016; Becker *et al.*, 2010). The lack of updated and localized data on medically important insects

limits the ability of health authorities to effectively predict outbreaks and manage vector populations. This persistent gap in knowledge continues to compromise effective public health interventions in Sokoto Metropolis.

1.3 Justification of the Study

This study is justified by the pressing need to generate current and location-specific data on the diversity, abundance, and breeding ecology of medically important insects in Sokoto Metropolis. Insect vector surveillance is a critical component of any vector-borne disease prevention and control strategy (WHO, 2017). Updated entomological data are essential for planning and implementing targeted, sustainable, and cost-effective vector control programs, especially in resource-limited settings like Sokoto (Becker *et al.*, 2010).

Moreover, this study will inform local authorities, environmental health officers, and policymakers about the prevailing insect vector situation, thus aiding in the development of integrated vector management (IVM) strategies as recommended by WHO (WHO, 2020). The findings will also contribute to community-based health education, enabling residents to better understand and reduce their exposure to insect vectors and the diseases they transmit (Adeleke *et al.*, 2010).

Given the ongoing environmental changes, rapid urbanization, and climatic variability in Sokoto, a systematic and data-driven approach to vector surveillance is more critical than ever. This study will provide a scientific basis for identifying high-risk areas, predicting periods of increased insect activity, and improving public health preparedness and response in Sokoto Metropolis.

1.4 Aim and Objectives of the Study

The aim of this study is to investigate the diversity and distribution of medically important insect species in Sokoto Metropolis.

Objectives of the Study are:

1. To identify and classify the medically important insect species present in Sokoto Metropolis.
2. To determine the abundance and spatial distribution of these insects across selected areas of the metropolis.
3. To assess the major breeding sites and environmental conditions that support the proliferation of these insect vectors.

CHAPTER TWO

2.0

LITERATURE REVIEW

2.1 Introduction

Insects play a significant role in the ecology of disease transmission and public health, particularly in tropical and subtropical regions such as Nigeria. A large number of insect species are of medical importance due to their capacity to act as vectors of disease-causing organisms' viruses, bacteria, protozoa, and helminths. These insects not only serve as passive mechanical carriers but also as biological vectors in which pathogens undergo part of their life cycle before being transmitted to humans or animals (Service, 2012).

In urban areas like Sokoto Metropolis, which experience high population density, inadequate waste management, and seasonal climatic changes, the risk of insect-borne disease transmission is intensified. Medically important insect groups such as mosquitoes, houseflies, sandflies, and fleas thrive in these environments due to the presence of open drains, stagnant water, refuse dumps, and poor housing conditions (Oladimeji *et al.*, 2018). These insects contribute significantly to the burden of malaria, dengue fever, lymphatic filariasis, leishmaniasis, and typhus, all of which are

classified by the World Health Organization (WHO) as neglected tropical diseases (NTDs) (WHO, 2021).

The distribution and diversity of insect vectors are influenced by ecological, environmental, and anthropogenic factors. Temperature, humidity, availability of breeding sites, and human activity play crucial roles in shaping insect populations across different landscapes (Bayoh and Lindsay, 2003; Okorie *et al.*, 2014). While some species exhibit seasonal abundance, others persist year-round depending on local environmental conditions. Urbanization, without adequate public health infrastructure, has been linked to increased breeding habitats and changes in vector behavior, such as feeding patterns and host preferences (Ogundele *et al.*, 2020).

Despite the growing importance of entomological surveillance in Nigeria's public health strategy, there is a noticeable gap in data on the spatial distribution and diversity of medically important insects in certain northern urban areas, including Sokoto. Most existing studies have concentrated on malaria vectors in southern regions, leaving northern Nigeria underrepresented in vector ecology literature (Okorie *et al.*, 2014). Given the public health implications of vector-borne diseases, it is essential to establish a baseline of insect vector diversity and distribution to inform control measures.

This literature review aims to provide a conceptual and empirical foundation for the present study by examining existing research on the classification, ecological preferences, public health relevance, and environmental determinants of medically important insects. The review will also highlight knowledge gaps relevant to Sokoto Metropolis and justify the necessity of the current investigation.

2.2 Concept of Medical Entomology

Medical entomology is a specialized branch of entomology that focuses on the study of arthropods of medical importance, particularly insects and arachnids that impact human and animal health through direct interaction or disease transmission. These include species that act as vectors, parasites, or pests, and are responsible for transmitting some of the world's most dangerous diseases, including malaria, dengue fever, yellow fever, leishmaniasis, trypanosomiasis, and filariasis (Service, 2012).

Medically important insects can exert their impact in three main ways:

1. **As disease vectors** – Transmitting pathogens such as viruses, bacteria, protozoa, and helminths. For example, *Anopheles* mosquitoes transmit *Plasmodium* spp. (malaria), *Aedes aegypti* transmits arboviruses such as dengue and Zika, and tsetse flies (*Glossina* spp.) transmit *Trypanosoma brucei* (African sleeping sickness).

2. **As ectoparasites** – Feeding on human or animal blood and causing skin irritation, secondary infections, and allergic reactions. Examples include lice, fleas, and bedbugs, which although not always vectors, can have significant nuisance value and psychological effects (Foil and Gorham, 2000).
3. **As mechanical vectors or contaminants** – Houseflies and cockroaches can carry pathogens on their body surfaces or in their digestive tracts and deposit them on food, utensils, or wounds, leading to outbreaks of diseases like typhoid fever, cholera, and dysentery (Oladimeji *et al.*, 2018).

Medical entomology also plays a crucial role in epidemiology, vector control, and disease prevention. By identifying the behavior, breeding habitats, feeding patterns, and population dynamics of vectors, public health officials can design targeted interventions such as insecticide-treated nets (ITNs), indoor residual spraying (IRS), and environmental sanitation programs (Becker *et al.*, 2010).

The discipline integrates knowledge from zoology, ecology, pathology, microbiology, and public health to address vector-borne disease challenges. In tropical environments such as Sokoto Metropolis, where climatic conditions and human practices create suitable breeding conditions, understanding medical entomology is essential for effective disease surveillance and control.

Despite its importance, medical entomology remains underdeveloped in many parts of sub-Saharan Africa due to limited funding, lack of entomological expertise, and inadequate data collection. As a result, many disease outbreaks occur without sufficient entomological context to guide control strategies (Okorie *et al.*, 2014). Therefore, research focused on vector diversity and distribution in urban centers like Sokoto is critical for expanding the scope of medical entomology and informing public health action.

2.3 Classification and Identification of Medically Important Insects

The classification and accurate identification of medically important insects are essential components of medical entomology, especially for effective disease control and vector surveillance. Medically important insects are typically grouped based on their taxonomic order, morphological features, and their role in disease transmission either as biological vectors, mechanical carriers, or nuisance pests (Service, 2012). Correct classification enables entomologists and public health professionals to determine which species are responsible for transmitting specific pathogens, understand their behavior and life cycles, and implement targeted vector control strategies.

2.3.1 Major Orders of Medically Important Insects

Medically significant insects fall into several insect orders, each containing species with a proven or suspected role in human disease:

- **Diptera (True Flies and Mosquitoes)**
 - This is the most important order in terms of disease transmission. It includes:
 - *Anopheles*, *Culex*, and *Aedes* mosquitoes, which transmit malaria, filariasis, yellow fever, dengue, chikungunya, and Zika virus.
 - *Glossina* species (tsetse flies), which transmit African trypanosomiasis.
 - *Phlebotomus* and *Lutzomyia* species (sandflies), responsible for leishmaniasis.
 - *Simulium* species (blackflies), which transmit onchocerciasis (river blindness).
- **Siphonaptera (Fleas)**
 - Fleas such as *Xenopsylla cheopis* are known vectors of plague (*Yersinia pestis*) and murine typhus (*Rickettsia typhi*) (Becker *et al.*, 2010).

- **Phthiraptera (Lice)**

- Lice include:

- *Pediculus humanus humanus* (body louse) – vector of epidemic typhus, relapsing fever, and trench fever.
- *Pediculus humanus capitis* (head louse) – mostly a nuisance species, though occasionally associated with minor infections.
- *Phthirus pubis* (pubic louse) – causes pruritic infestations.

- **Hemiptera (True Bugs)**

Members such as *Triatoma infestans* (kissing bug) are vectors of Chagas disease caused by *Trypanosoma cruzi*. While not endemic in Nigeria, their relevance in global health is significant.

- **Coleoptera and Blattodea (Beetles and Cockroaches)**

While not biological vectors, cockroaches (e.g., *Periplaneta americana*) are common mechanical carriers of pathogens due to their movement between unsanitary environments and human dwellings.

2.3.2 Techniques for Identification

Accurate identification of insect species is critical for determining their medical relevance and guiding control strategies. The identification process includes:

- **Morphological Identification**

This is the most commonly used technique, relying on visual characteristics such as wing venation, antenna type, mouthparts, leg structure, body segmentation, and color patterns. Dichotomous keys are frequently used in field identification (Service, 2012).

- **Microscopic Examination**

Particularly for small insects like mosquitoes and sandflies, the use of compound microscopes helps observe fine structures such as scales on wings, pupal structures, or genitalia, which are often necessary for species-level identification.

- **Larval and Pupal Identification**

For aquatic insects like mosquitoes, larval and pupal stages can also be identified using structural features like the siphon, anal gills, and head capsule (Becker *et al.*, 2010).

- **Molecular and Biochemical Methods**

Modern identification techniques include:

- PCR (Polymerase Chain Reaction) for species-specific DNA sequences.
- ELISA for blood meal analysis in blood-feeding insects.
- DNA barcoding, which uses mitochondrial genes like COI for identification.

These methods are particularly useful when morphological differences are subtle or specimens are damaged, or for detecting cryptic species (Foster *et al.*, 2017).

2.3.3 Importance of Correct Classification

Proper classification and identification serve the following purposes:

- **Vector incrimination:** Establishing which species are responsible for transmission of particular diseases.
- **Targeted control:** Designing control measures tailored to species-specific habitats, breeding behavior, and feeding preferences.

- **Surveillance and risk mapping:** Monitoring population changes over time and identifying areas of high transmission risk.
- **Resistance management:** Detecting species-specific insecticide resistance patterns to inform sustainable control strategies (Hemingway *et al.*, 2016).

In Nigeria, and particularly in regions like Sokoto Metropolis, there is a growing need for localized identification studies to support region-specific disease control efforts. Few studies have comprehensively cataloged the range of insect species in northern urban settings, and this hinders integrated vector management initiatives (Okorie *et al.*, 2014).

2.4 Distribution and Abundance of Insect Vectors in Urban Areas

The distribution and abundance of medically important insect species vary significantly based on ecological, environmental, and anthropogenic factors. In urban areas like Sokoto Metropolis characterized by increasing population density, poor sanitation, unplanned urban growth, and seasonal climatic changes these conditions combine to create ideal habitats for a wide range of insect vectors. Understanding their spatial patterns and population densities is critical to designing effective vector control strategies and preventing disease outbreaks (WHO, 2021).

2.4.1 Environmental Determinants of Distribution

The **spatial distribution** of insect vectors is largely influenced by factors such as:

- **Temperature and Humidity:** Warmer climates and high humidity levels promote faster developmental cycles in insect vectors, especially mosquitoes, whose aquatic stages depend on ambient temperatures for survival and emergence (Bayoh and Lindsay, 2003). Sokoto, located in the semi-arid region of Nigeria, experiences a dry season and a brief rainy season, during which standing water becomes available for mosquito breeding.
- **Rainfall and Water Accumulation:** Rainfall events create ephemeral aquatic habitats like puddles, clogged gutters, and discarded containers that support mosquito breeding. The abundance of *Culex* and *Aedes* species often spikes following periods of heavy rain, while *Anopheles* mosquitoes prefer more permanent, clean water bodies (Olayemi and Ande, 2008).
- **Vegetation and Land Use:** Urban green spaces, overgrown bushes, and unmanaged refuse dumps provide resting and breeding areas for vectors such as houseflies (*Musca domestica*) and sandflies (*Phlebotomus* spp.) (Okorie *et al.*, 2014).

2.4.2 Urbanization and Human Activities

Urbanization leads to increased vector-human contact due to several factors:

- **Inadequate Waste Management:** Open dumpsites, overflowing septic tanks, and refuse heaps are common in many urban Nigerian neighborhoods and provide food sources and breeding sites for flies, cockroaches, and mosquitoes (Oladimeji *et al.*, 2018).
- **Poor Drainage and Stagnant Water:** Improper drainage systems lead to stagnant pools, which become breeding habitats for *Culex* and *Anopheles* mosquitoes. These habitats are especially common in low-income, poorly planned neighborhoods.
- **Water Storage Practices:** Due to intermittent water supply, residents often store water in containers, which if left uncovered, become ideal habitats for *Aedes aegypti* the vector of dengue, yellow fever, and Zika virus (Adeleke *et al.*, 2013).

2.4.3 Seasonal Variation in Abundance

Insect vector populations in Sokoto and similar tropical environments typically exhibit seasonal trends:

- **Rainy Season (June–September):** Mosquitoes are most abundant during this period due to an increase in breeding habitats, particularly for *Anopheles gambiae* and *Culex quinquefasciatus*. The rainy season is often accompanied by **spikes in malaria and arboviral infections** (Afolabi *et al.*, 2016).
- **Dry Season (October–May):** While vector abundance decreases, indoor resting mosquitoes and flies may persist in shaded, humid shelters, maintaining low-level transmission. Flies like *Musca domestica* remain active year-round where sanitation is poor.

2.4.4 Spatial Heterogeneity within Cities

Even within urban centers like Sokoto, insect vector distribution is not uniform. Differences in housing structure, sanitation, vegetation cover, and socio-economic status create microhabitats that influence where insect populations thrive. For example:

- **High-density, low-income areas** tend to have higher vector burdens due to poor infrastructure and sanitation.
- **Commercial markets** attract flies and cockroaches due to food waste.
- **Outskirts and peri-urban zones** may have more mosquitoes due to proximity to stagnant water bodies and vegetation (Ogundele *et al.*, 2020).

Mapping these variations through entomological surveys allows for targeted interventions such as larviciding, sanitation campaigns, and public education.

2.4.5 Importance of Urban Vector Surveillance

Regular monitoring of vector populations enables:

- Early detection of disease outbreaks (e.g., dengue, malaria).
- Informed planning for vector control measures.
- Identification of new or invasive species, which may introduce new disease threats.
- Evaluation of the impact of ongoing interventions (WHO, 2021).

Sokoto Metropolis, with its mix of urban and peri-urban areas, provides a useful setting for such assessments. Yet, as noted in recent reviews, northern Nigerian cities are underrepresented in national entomological mapping efforts (Okorie *et al.*, 2014). The current study aims to fill that gap by establishing baseline data on the abundance and spatial distribution of medically important insect species in Sokoto.

2.5 Environmental Conditions Supporting Vector Proliferation

The proliferation of medically important insect vectors is closely tied to specific environmental conditions that support their survival, development, and reproduction.

Insects such as mosquitoes, flies, fleas, lice, and sandflies exploit ecological niches created by both natural and man-made factors. In urban environments like Sokoto Metropolis, a combination of climatic factors, poor waste management, and human practices contribute to persistent vector presence and increased disease risk.

2.5.1 Climatic Conditions: Temperature and Humidity

Temperature and humidity are among the most critical environmental variables affecting insect development and survival. Most medically important insects are ectothermic, meaning their body temperature and biological functions are regulated by ambient temperatures. Warmer conditions accelerate life cycles, leading to faster development of eggs, larvae, and pupae, particularly in mosquitoes and houseflies (Bayoh and Lindsay, 2003).

In Sokoto, which experiences high diurnal temperatures (often exceeding 40°C in the dry season), the mosquito life cycle may complete within 7–10 days during peak warmth. However, excessively high temperatures without sufficient humidity can be detrimental, limiting the survival of immature stages. Relative humidity also affects adult insect longevity and host-seeking behavior; for instance, *Anopheles* mosquitoes require at least 50–60% relative humidity for effective nocturnal activity (Gimnig *et al.*, 2001).

2.5.2 Presence of Water Bodies and Breeding Sites

The availability of standing or stagnant water is one of the most influential environmental factors for insect vector proliferation, especially for mosquitoes.

Common breeding sites include:

- Blocked drainage systems and gutters
- Open containers and water storage tanks
- Disused tires and plastic waste
- Irrigation canals and rice fields
- Septic tanks and pit latrines

Species like *Culex quinquefasciatus* breed in polluted water, while *Aedes aegypti* prefer clean water in artificial containers. The short but intense rainy season in Sokoto leads to rapid formation of these water bodies, creating multiple larval habitats that support seasonal vector population booms (Adeleke *et al.*, 2013).

2.5.3 Poor Sanitation and Waste Disposal Practices

Inefficient waste management contributes significantly to the spread of filth flies, cockroaches, and mosquitoes. Urban slums and markets in Sokoto often lack proper refuse collection, and organic waste accumulates in open spaces. These conditions attract houseflies (*Musca domestica*), which breed in decomposing matter, faeces, and open drains, facilitating the mechanical transmission of enteric pathogens like *Salmonella*, *Shigella*, and *E. coli* (Oladimeji *et al.*, 2018).

Moreover, rodents and domestic animals scavenging in waste dumps further spread insect pests, contributing to infestations in nearby homes and food establishments.

2.5.4 Housing and Urban Infrastructure

The type and condition of housing in a given area also influence vector abundance. Poorly ventilated buildings, homes without window screens, and structures with cracked walls or leaking roofs allow easy access and shelter for mosquitoes, cockroaches, and bedbugs. Overcrowded settlements with high human-vector contact rates increase the chances of transmission of malaria, yellow fever, and typhus (Ogundele *et al.*, 2020).

In contrast, well-planned residential areas with access to piped water, proper drainage, and enclosed waste disposal systems exhibit lower vector densities.

2.5.5 Socioeconomic and Behavioral Factors

Environmental risk factors for vector proliferation are often amplified by human behavior:

- Storing water in open containers (due to unreliable water supply) encourages *Aedes* mosquito breeding.
- Improper disposal of plastic and metallic waste provides containers that collect rainwater.
- Lack of knowledge about vector breeding sites leads to poor community participation in vector control initiatives.
- Nomadic and peri-urban dwellings, common in Sokoto outskirts, often rely on open defecation and water from contaminated wells, contributing to fly-borne and water-borne diseases.

2.5.6 Vegetation and Microclimatic Conditions

Vegetation cover and shade create favorable microclimates for vector resting and survival. *Anopheles* mosquitoes and sandflies prefer resting in shaded, humid environments such as bushes, shrubs, and around animal shelters. Areas with irrigated gardens, flowerbeds, and uncut grasses offer protection and humidity for day-time

resting (Service, 2012). In Sokoto, irrigated agricultural zones within the metropolis serve as hotspots for sandflies and mosquitoes, particularly during the dry season.

2.5.7 Summary of Key Environmental Influences

Environmental Factor	Influence on Insect Vectors
Temperature and Humidity	Affects development speed and adult survival
Rainfall and Standing Water	Creates breeding habitats for mosquitoes
Poor Waste Disposal	Supports flies, cockroaches, and mosquito breeding
Housing and Sanitation	Influences human-vector contact rates
Vegetation and Shaded Areas	Provides shelter for resting adult vectors
Water Storage Practices	Promotes <i>Aedes</i> and <i>Culex</i> proliferation

A detailed understanding of these factors is necessary for vector surveillance, spatial risk mapping, and public health policy development. In Sokoto, urban growth and poor environmental management make these conditions increasingly favorable for vector persistence unless effective intervention strategies are employed.

2.6 Medical and Public Health Importance of Insect Vectors

Medically important insects represent a substantial public health threat globally, especially in tropical and subtropical regions where climatic and environmental

conditions support their proliferation. Insect vectors are responsible for the biological transmission of a wide variety of pathogens, including viruses, protozoa, helminths, and bacteria that cause significant morbidity, mortality, and economic loss. In Nigeria, diseases transmitted by insects such as malaria, yellow fever, lymphatic filariasis, and leishmaniasis remain endemic, despite public health efforts (WHO, 2021).

2.6.1 Vector-Borne Diseases of Global and Local Concern

Vector-borne diseases account for over 17% of all infectious diseases and cause more than 700,000 deaths annually worldwide (WHO, 2021). The impact is particularly severe in low-income countries, where healthcare systems are overburdened and vector control strategies are often poorly implemented. Table 2.1 summarizes key diseases associated with major insect vectors relevant to urban and peri-urban settings like Sokoto.

Table 2.1: Common Vector-Borne Diseases and Associated Insects

Disease	Vector Insect	Causative Agent
Malaria	<i>Anopheles</i> mosquitoes	<i>Plasmodium</i> spp. (protozoa)
Yellow fever	<i>Aedes aegypti</i>	Yellow fever virus
Dengue fever	<i>Aedes aegypti</i>	Dengue virus
Lymphatic filariasis	<i>Culex</i> spp., <i>Anopheles</i> spp.	<i>Wuchereria bancrofti</i> (helminth)
Leishmaniasis	<i>Phlebotomus</i> spp. (sandflies)	<i>Leishmania</i> spp. (protozoa)
Trypanosomiasis	<i>Glossina</i> spp. (tsetse fly)	<i>Trypanosoma brucei</i> (protozoa)
Onchocerciasis	<i>Simulium</i> spp. (blackfly)	<i>Onchocerca volvulus</i> (helminth)

(Source: WHO, 2021; Becker *et al.*, 2010)

2.6.2 Economic and Health Burden

The economic toll of vector-borne diseases is substantial. For instance, malaria alone causes an estimated loss of billions of dollars annually in Africa due to healthcare costs, lost productivity, and reduced economic growth (Aregawi *et al.*, 2020). In Sokoto and other regions of Northern Nigeria, seasonal malaria outbreaks are common, particularly during and after the rainy season. Vector infestations also

disrupt daily life and productivity, especially in densely populated low-income urban areas.

Moreover, insect infestations cause direct medical problems beyond disease transmission. Flea bites, for example, can cause dermatitis and allergic reactions. Lice infestations can result in skin infections and social stigma. Bedbugs, although not proven disease vectors, cause psychological stress and skin irritation, especially in overcrowded settlements.

2.6.3 Role in Epidemic Outbreaks

Insect vectors are often at the center of epidemic outbreaks, particularly in areas where environmental changes or disruptions (e.g., flooding, displacement, poor sanitation) create breeding opportunities. For example, outbreaks of yellow fever in Nigeria have been associated with *Aedes aegypti* in urban settings where water storage containers are common (WHO, 2019). Similarly, the expansion of *Phlebotomus* spp. due to deforestation and urban encroachment has increased the incidence of cutaneous leishmaniasis in northern Nigeria (Omer *et al.*, 2017).

2.6.4 Resistance and Vector Adaptation

A growing concern is the adaptation of insect vectors to urban environments and their increasing resistance to insecticides. Studies in Nigeria have shown resistance in

Anopheles gambiae and *Aedes aegypti* populations to common pyrethroids used in insecticide-treated nets (ITNs) and indoor residual spraying (IRS) (Hemingway *et al.*, 2016). Resistance undermines existing vector control programs and necessitates **continued entomological surveillance**.

Furthermore, vectors are demonstrating changes in biting behavior, with some species shifting from indoor to outdoor biting, or becoming more active during daytime hours, thereby evading traditional control interventions. Such behavioral plasticity further complicates control efforts, especially in urban environments like Sokoto where multiple vector species co-exist.

2.6.5 Public Health Implications

The proliferation of insect vectors has significant implications for public health planning. In regions like Sokoto, where healthcare access is limited and environmental sanitation is poor, a comprehensive understanding of local vector species is critical to:

- Identify hotspots of transmission
- Plan integrated vector management (IVM) strategies
- Support community-based interventions such as environmental cleanups

- Guide mass drug administration (MDA) for diseases like onchocerciasis and lymphatic filariasis
- Predict and prevent emerging disease outbreaks

Public health authorities must also strengthen community awareness on vector breeding prevention, personal protection measures, and early reporting of symptoms.

2.7 Studies on Insect Vector Diversity in Nigeria

Nigeria, due to its vast ecological and climatic diversity, is home to a wide range of insect vector species. Studies conducted across various regions have demonstrated significant differences in vector species composition, abundance, and disease transmission dynamics. These studies provide essential insight into vector ecology, yet much of the research has been concentrated in southern and central regions, leaving areas such as Sokoto Metropolis in the northwest relatively underexplored (Okorie *et al.*, 2014).

2.7.1 National Overview of Vector Diversity Research

Several entomological surveys across Nigeria have identified mosquitoes, flies, lice, sandflies, and blackflies as key vectors of disease. For example, Mbanugo and Okafor (2016) investigated mosquito species in Awka, southeastern Nigeria, and found a high

prevalence of *Anopheles gambiae*, *Aedes aegypti*, and *Culex quinquefasciatus*, which are major vectors of malaria, yellow fever, and filariasis, respectively.

In another study, Afolabi *et al.* (2016) examined seasonal mosquito dynamics in southwestern Nigeria, revealing the dominance of *Anopheles gambiae* during the rainy season and *Culex* species in polluted urban environments. These findings highlight the influence of urbanization and climate on vector composition.

However, studies like these are limited in the northern regions of the country, including Sokoto, where ecological conditions differ significantly and may influence vector diversity in distinct ways.

2.7.2 Northern Nigeria and the Knowledge Gap

While some research has been conducted in northern Nigeria, the volume and detail are far less than in the south. Okorie *et al.* (2014) noted that entomological data from northern Nigeria were patchy, outdated, or nonexistent, particularly concerning the distribution of non-mosquito vectors such as sandflies, lice, and flies. Yet, northern states like Sokoto experience significant burdens of neglected tropical diseases (NTDs) such as onchocerciasis, lymphatic filariasis, and cutaneous leishmaniasis, all transmitted by insect vectors.

A study by Ibrahim *et al.* (2013) in Zaria (Kaduna State) documented a wide range of mosquito species and associated breeding habitats in urban and peri-urban settings, underscoring the need for localized surveys to inform control strategies.

2.7.3 Importance of Vector Mapping and Biodiversity Assessments

Understanding the diversity and spatial distribution of insect vectors is crucial for designing targeted vector control interventions. Vector mapping projects, such as those supported by the Nigerian Federal Ministry of Health and partners like WHO and the Carter Center, have focused mainly on mapping vectors of malaria and onchocerciasis, often excluding other insect groups of medical relevance (WHO, 2021).

Moreover, emerging and re-emerging vector-borne diseases like dengue, yellow fever, and Rift Valley fever require broader surveillance of vectors such as *Aedes*, *Phlebotomus*, and *Simulium*. Without updated data from underrepresented areas like Sokoto, national control programs risk being incomplete or misdirected.

2.7.4 Sokoto Metropolis: A Research Priority

Sokoto, located in Nigeria's Sudan savanna zone, has unique ecological and sociocultural characteristics that influence vector distribution. The presence of seasonal water bodies, poor drainage, frequent open defecation, and extensive animal

husbandry may support diverse insect populations beyond mosquitoes. However, few comprehensive entomological studies have been published for this region.

Preliminary reports from local health offices suggest seasonal increases in mosquito nuisance and fly-borne infections, especially during the rainy season, but lack empirical support. Thus, detailed studies on insect vector diversity in Sokoto are urgently needed to establish a baseline database for academic, public health, and policy use.

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Study Area

Sokoto Metropolis is situated in the Sudan savanna ecological zone, typified by semi-arid conditions, seasonal rainfall, and extreme daily temperatures that shape insect ecology. The area experiences a rainy season between June and September, during which pools of stagnant water and increased humidity create favorable breeding conditions for various vector species, particularly mosquitoes and filth flies (Bayoh and Lindsay, 2003; NIMET, 2022). Human activities such as open defecation, indiscriminate refuse dumping, and animal rearing further contribute to the proliferation of disease vectors, as observed in similar studies across Northern Nigeria (Oladimeji *et al.*, 2018).

3.2 Research Design

A descriptive cross-sectional design is selected for its effectiveness in capturing ecological and spatial data at a given time point, which is particularly suitable for documenting the occurrence and diversity of vectors in a specific area (Silver, 2008). The study focuses on simultaneous collection and analysis of data from multiple

locations within Sokoto to provide a comparative understanding of vector populations and environmental risk factors.

3.3 Sampling Framework and Site Selection

Sampling locations are purposively selected based on ecological stratification, including proximity to water bodies, human population density, sanitation level, and vegetation cover. This approach follows methods employed in vector mapping studies by Okorie *et al.* (2014), where environmental heterogeneity influenced species distribution. The six selected sites represent a gradient of urban to peri-urban conditions, thereby capturing a broader spectrum of habitats and vector types.

3.4 Insect Vector Collection Techniques

Comprehensive vector surveillance involves the deployment of multiple collection methods, each tailored to the behavioral and ecological characteristics of the target insect species.

Mosquito Collection

Mosquitoes will be collected using both adult and larval sampling techniques, ensuring representation across life stages.

- CDC Light Traps: Positioned near sleeping areas from dusk to dawn (6:00 PM to 6:00 AM), these traps are effective for capturing nocturnal mosquitoes,

including *Anopheles*, *Aedes*, and *Culex* species. This method has been widely validated in WHO entomological manuals (WHO, 2013) and is a standard for evaluating indoor and 3.5.2 Flies and Sandflies

- Baited Traps and Sticky Papers: These will be placed in refuse sites, abattoirs, and latrines to trap houseflies (*Musca domestica*) and blowflies, both of which are mechanical vectors of diarrheal pathogens.
- Light Traps and Sticky Interceptors: Used during dusk to capture sandflies (*Phlebotomus* spp.), especially in areas with dense vegetation or animal shelters (Service, 2012).
- Sweep Nets: Useful for fly collection in open spaces and vegetation-dense areas.

3.5 Identification and Classification

Specimens will be identified to genus and species level using morphological taxonomic keys provided by Service (2012), WHO (2013), and Becker *et al.* (2010). Specific diagnostic features such as wing venation, antennae shape, siphon structures, and genitalia will be examined under compound microscopes.

Insects will be categorized into:

- Diptera (mosquitoes, flies, sandflies)
- Siphonaptera (fleas)
- Phthiraptera (lice)
- Others, where relevant

Species diversity and abundance will be logged, and voucher specimens will be preserved for further verification.

3.6 Data Analysis

Descriptive statistics will summarize species frequency, relative abundance, and site-level differences. Biodiversity indices' Shannon-Wiener Index (H') will be used to compare diversity across sites. ANOVA and Chi-square tests will assess the statistical significance of differences in insect abundance across locations.

CHAPTER FOUR

4.0

RESULTS

4.1 CDC Light Traps (2 Complete Sets)

A total of sixty mosquito specimens were collected from Kofar Kware area, Magajin Gari Road, Sokoto, using two complete sets of CDC light traps placed both indoors and outdoors. The mosquitoes belonged to three genera: *Anopheles*, *Aedes*, and *Culex*. Among these, *Culex* species were the most dominant, accounting for forty-two individuals, which represents 70% of the total catch. This high abundance indicates that *Culex* mosquitoes are the prevailing species in the study area, suggesting that environmental conditions such as stagnant water and poor drainage may favor their breeding and survival (Table 4.1).

Both *Anopheles* and *Aedes* species were less represented, each with nine individuals, making up 15% of the total mosquito population. The *Anopheles* species, known vectors of malaria, were collected mainly outdoors, showing a preference for outdoor resting and biting behavior (exophilic tendency). Similarly, *Aedes* species, which are responsible for the transmission of yellow fever and dengue, were found exclusively outdoors, indicating their strong exophagic and exophilic behavior.

Table 4.1: Number of Mosquitoes trapped by CDC Light Traps in the Study Area

Species	Indoor		Outdoor		Total	Abundance (%)
	Male	Female	Male	Female		
Anopheles	0	2	1	6	9	15
Aedes	0	0	4	5	9	15
Culex	1	5	21	15	42	70

4.2 Light Traps with Spray Sheet

A total of four mosquito specimens were collected using light traps with spray sheets in the study area. The collected species belonged to two genera, *Anopheles* and *Culex*. Out of these, *Culex* species were the most abundant, with three individuals, representing 75% of the total catch. The predominance of *Culex* mosquitoes in this trapping method suggests that they are the most adaptable and prevalent species in the environment, possibly due to favorable breeding sites such as open drains, stagnant water, and other organic-rich habitats.

Only one *Anopheles* specimen (25%) was recorded, while no *Aedes* mosquitoes were captured using this method. The presence of *Anopheles* species, though in low numbers, is still of epidemiological significance, as it indicates the potential risk of malaria transmission within the area. The absence of *Aedes* species in this collection may be due to their preference for specific daytime breeding and biting habits, which make them less susceptible to being trapped by light traps operated at night (Table 2).

Table 4.2: Number of Mosquitoes trapped by Light Traps with Spray sheet in the Study Area

Species	Male	Female	Total	Abundance (%)
Anopheles	0	1	1	25
Aedes	0	0	0	0
Culex	1	2	3	75

4.3 Light Traps and Sticky Interceptors

A total of four mosquito specimens were collected using light traps combined with sticky interceptors in the Kofar Kware area, Magajin Gari Road, Sokoto. The captured mosquitoes belonged to two genera, *Anopheles* and *Culex*, each contributing two individuals, representing an equal abundance of 50% each. No *Aedes* species were recorded using this collection method.

The equal distribution of *Anopheles* and *Culex* species indicates that both genera were attracted to the light traps and sticky interceptors in similar proportions. The presence of *Anopheles* species is significant, as it points to the continued existence of malaria vectors in the area, while the *Culex* species, known for transmitting filarial and other viral diseases, also play a major role in local vector ecology (Table 3).

The absence of *Aedes* mosquitoes may be attributed to their diurnal biting behavior and specific breeding preferences, which make them less likely to be caught by nocturnal light-based traps. Overall, the results suggest that both *Anopheles* and *Culex* species are actively present in the area, maintaining potential risks for mosquito-borne diseases such as malaria and filariasis.

Table 4.3: Number of Mosquitoes Trapped by Light Traps and Sticky Interceptors in the Study Ara

Species	Male	Female	Total	Abundance (%)
Anopheles	1	1	2	50
Aedes	0	0	0	0
Culex	1	1	2	50

4.4 Baited Traps and Sticky Paper

A total of seven medically important insect specimens were collected using baited traps and sticky paper in the Kofar Kware area, Magajin Gari Road, Sokoto. The insects comprised two species houseflies (*Musca domestica*) and lice (*Pediculus* spp.). Among these, houseflies were the most abundant, with five individuals representing 71.4% of the total collection. The high number of houseflies indicates their wide distribution and adaptability to the prevailing environmental conditions, particularly areas with poor sanitation, open waste disposal, and organic matter, which serve as favorable breeding and feeding sites (Table 4).

Lice, on the other hand, were less common, accounting for two individuals (28.6%). Their lower abundance may be due to their parasitic lifestyle, as they are typically associated with human or animal hosts rather than free-living environments.

Table 4.4: Number of Housefly and Lice Trapped by Baited Traps and Sticky Papers in the Study Area

Species	Numbers	Total	Abundance (%)
Housefly	5	5	71.4
Lice	2	2	28.6
Total	7	7	100

CHAPTER FIVE

5.1 Discussion

The collection of medically important insects from Kofar Kware, Magajin Gari Road, Sokoto, revealed a predominance of *Culex* species across the various trapping methods employed. This pattern is consistent with previous findings in Nigeria and other tropical regions, where *Culex* mosquitoes are often the dominant species in urban environments (Adesina *et al.*, 2024; Samaila *et al.*, 2022). In this study, *Culex* accounted for 70% of the total catch in CDC light traps, 75% in light traps with spray sheets, and 50% in light traps combined with sticky interceptors. The dominance of *Culex* may be attributed to the availability of suitable breeding sites such as stagnant water, blocked drains, and organic waste materials, which are common in urban settings (Ogbu *et al.*, 2023). *Culex quinquefasciatus*, in particular, is known for its adaptability to polluted environments and its role as a vector of lymphatic filariasis and West Nile virus (Yakubu *et al.*, 2023; WHO, 2024).

Although less abundant, the presence of *Anopheles* species in both indoor and outdoor traps is of epidemiological importance, as they are the principal vectors of malaria. In this study, *Anopheles* mosquitoes were more abundant outdoors than indoors, suggesting a preference for outdoor biting and resting behavior (exophilic tendency).

This observation agrees with recent reports indicating that residual malaria transmission persists due to outdoor and early-evening biting by *Anopheles* mosquitoes, which limits the effectiveness of indoor control measures such as insecticide-treated nets (Okorie *et al.*, 2023; Fuseini *et al.*, 2025).

Aedes species were found only in the outdoor CDC light traps and were absent in other trap types. Their absence in indoor and night-based traps could be due to their diurnal feeding pattern and preference for artificial containers as breeding sites, making them less susceptible to nocturnal light-based trapping (Suleiman *et al.*, 2022; Adeleke *et al.*, 2023). *Aedes aegypti* and *Aedes albopictus* are important vectors of yellow fever, dengue, and chikungunya, and their detection even in low numbers indicates potential risk for arboviral disease transmission in the area (WHO, 2024).

Comparison among trapping methods showed that the CDC light traps captured more mosquitoes than the spray sheet or sticky interceptors, emphasizing that different traps vary in efficiency depending on species behavior and attractant type (Abdullahi *et al.*, 2023). The baited traps and sticky paper captured mainly non-mosquito medically important insects such as houseflies (*Musca domestica*) and lice (*Pediculus* spp.), with houseflies being the most dominant (71.4%). Houseflies are well-known mechanical vectors capable of transmitting over 100 pathogens, including those causing cholera,

typhoid, and dysentery (Nazari *et al.*, 2019; Sawabe *et al.*, 2020). Their abundance in the area suggests poor environmental sanitation and waste management, which create conducive breeding conditions (Ahmed *et al.*, 2023).

The detection of lice, though few, is noteworthy since they are obligate ectoparasites that can serve as vectors for epidemic typhus and relapsing fever (El-Bahnasawy *et al.*, 2022). Their presence may reflect poor personal hygiene or close human-animal contact within the local community.

Overall, the findings from this study indicate that *Culex* species dominate the mosquito fauna of Kofar Kware, with *Anopheles* and *Aedes* also present in smaller proportions. The abundance of *Culex* and the presence of other disease vectors highlight the need for continuous entomological surveillance and integrated vector management (IVM) approaches that include environmental sanitation, larval source management, and community health education (WHO, 2024).

Conclusion

The present study investigated the diversity and abundance of medically important insects collected from Kofar Kware, Magajin Gari Road, Sokoto, using different trapping methods. The findings revealed that *Culex* mosquitoes were the most abundant species across all trap types, followed by *Anopheles* and *Aedes*. The

predominance of *Culex* species suggests that the area provides suitable breeding habitats such as stagnant water and open drains that favor their proliferation. The detection of *Anopheles* species, though in lower numbers, signifies the persistence of malaria vectors, particularly those exhibiting outdoor biting behavior. The occasional occurrence of *Aedes* mosquitoes indicates the potential risk of arboviral diseases such as yellow fever and dengue.

In addition, non-mosquito vectors such as houseflies (*Musca domestica*) and lice (*Pediculus* spp.) were captured, underscoring the presence of other vectors of public health importance. The abundance of houseflies highlights potential challenges associated with poor environmental sanitation, while the presence of lice reflects possible hygiene-related concerns within the community.

Overall, the study demonstrates that Kofar Kware area supports a variety of medically important insect species capable of transmitting vector-borne and mechanically transmitted diseases. The findings emphasize the need for continuous entomological surveillance, improved sanitation, and integrated vector management strategies to mitigate disease risks associated with these insects.

Recommendations

1. Continuous monitoring of mosquito and other vector populations should be conducted to detect seasonal variations, species composition, and potential shifts in vector distribution patterns. This will help identify emerging risks and guide timely control measures.
2. The Sokoto State Environmental Protection Agency (SEPA) and local authorities should intensify efforts to eliminate stagnant water bodies, blocked drains, and open refuse dumps that serve as breeding sites for *Culex* and *Aedes* mosquitoes.
3. Community-based health campaigns should be organized to educate residents on the importance of proper waste disposal, personal hygiene, and the elimination of potential mosquito breeding habitats around homes.
4. Control efforts should combine environmental sanitation, larval source management, and selective use of insecticides where necessary. Integration of biological control methods (e.g., larvivorous fish, *Bacillus thuringiensis israelensis*) should also be encouraged to minimize chemical dependence.

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APPENDICES

QUESTIONNAIRE USMANU DANFODIYO UNIVERSITY, SOKOTO FACULTY OF SCIENCE DEPARTMENT OF ZOOLOGY

Dear Respondent,

This questionnaire is designed purely for academic purposes. The information you provide will be treated with strict confidentiality. Kindly answer the following questions sincerely.

SECTION A: SOCIO-DEMOGRAPHIC INFORMATION

1. Area/Location: _____
2. Serial Number: _____
3. Age Group:
 - ☐ Less than 20
 - ☐ 20–34
 - ☐ 35–50
 - ☐ Above 50
4. Gender:
 - ☐ Male
 - ☐ Female
5. Marital Status:
 - ☐ Single
 - ☐ Married
 - ☐ Divorced
 - ☐ Widowed
6. Educational Level:
 - ☐ No formal education
 - ☐ Primary
 - ☐ Secondary
 - ☐ Tertiary
 - ☐ Others (please specify): _____

SECTION B: KNOWLEDGE AND PERCEPTION OF MEDICALLY IMPORTANT INSECTS

7. Are you aware of any insects that can transmit diseases to humans?
☐ Yes
☐ No
8. If yes, which insect(s) do you know? (e.g., mosquitoes, houseflies, tsetse flies, etc.)
9. Have you or anyone in your household ever suffered from a disease caused by an insect?
☐ Yes
☐ No
10. If yes, specify the disease(s):
11. What type of environment do you often observe these insects in?
☐ Dirty surroundings
☐ Stagnant water
☐ Refuse dumps
☐ Bushy areas
☐ Others (specify): _____
12. In which season do you observe more of these insects?
☐ Rainy season
☐ Dry season
☐ Both
☐ Not sure
13. Which of the following medically important insects are common in your area?
(You may tick more than one)
☐ Mosquitoes
☐ Houseflies
☐ Tsetse flies
☐ Sandflies
☐ Cockroaches
☐ Fleas
☐ Bedbugs
☐ Others (specify): _____

SECTION C: INDIGENOUS USE OF INSECTS FOR MEDICINAL PURPOSES

14. Do you or your community use any insects for medicinal purposes?
☐ Yes
☐ No
15. If yes, which insect(s) are used?

16. What health conditions are treated using these insects?
17. How long have you or your community used these insects medicinally?
 - ☐ Less than 5 years
 - ☐ 5–10 years
 - ☐ 11–15 years
 - ☐ More than 15 years
18. Have you observed any side effects or health risks after using insects medicinally?
 - ☐ Yes
 - ☐ No
19. If yes, please describe the side effects or problems encountered:
20. In your opinion, do you believe insects play a positive role in traditional healthcare?
 - ☐ Yes
 - ☐ No
 - ☐ Not sure
21. What advice would you give for the proper and safe use of insects for medicinal or health purposes?

Thank you for your time and cooperation!