A Study Of Relationship Between *Anopheles* Vector Density And Malaria Transmission Dynamics In Urban Malaria Of Bikaner City, Rajasthan

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***Abstract*—Urban malaria continues to be a major public health concern in arid and semi-arid regions of India. It is important to note in this context that the current research explores the correlation between *Anopheles* vector density and malaria transmission dynamics. Specifically, this research will examine the interaction between *Anopheles* vector density and the dynamics of the spread of the disease in the urban setting of landscape of Bikaner city, Rajasthan. Entomological monitoring was done for a period of one year, starting in August 2022 to July 2023. During this period, five different regions in the city were covered—Eastern, Western, Northern, Southern, and Central regions of urban Bikaner. Four types of *Anopheles* were identified in the research—*Anopheles stephensi*, *Anopheles subpictus*, *Anopheles culicifacies*, and *Anopheles annularis*- were recorded, with *An. stephensi* emerging as the dominant urban vector. It was reported that the vector density peaked in monsoon and post-monsoon seasons, when there was an increase in the occurrence of malaria. The research highlights how urban infrastructure, water storage practices, and seasonal climatic factors collectively influence vector proliferation and malaria transmission in desert cities.**

***Keywords*—Urban malaria, *Anopheles stephensi*, vector density, breeding habitats, Bikaner, Rajasthan.**

I.INTRODUCTION

Malaria transmission in urban India has again come under focus because of increased urbanization, unplanned development activities, and changing environmental patterns. Unlike rural malaria dominated by *Anopheles culicifacies*, urban malaria is largely driven by container-breeding vectors such as *Anopheles stephensi*. The Bikaner city, lying in the arid Thar Desert area, offers an intriguing epidemiological scenario with low rainfall, high temperatures, water scarcity, and widespread artificial water pools. Despite arid conditions, malaria cases continue to be reported annually from Bikaner, indicating the adaptability of urban malaria vectors. Understanding vector density patterns, species composition, breeding ecology and seasonal survivorship is essential for effective malaria control strategies.

This study aims to establish a direct relationship between Anopheles vector density and malaria transmission dynamics in urban Bikaner using comprehensive field and hospital data.

II.MATERIALS AND METHODS

2.1 Study Area

Rajasthan is largest state in India which includes area about 3,42,239 square kilometres. It is located on the north-western side of the India, where it comprises most of the wide and inhospitable Thar Desert and shares a border with the Pakistan while, Bikaner is situated at latitude and longitude 28.0271380, 73.302155 respectively. Bikaner is a desert city located in the northwest of Rajasthan, with a semi-arid climate characterized by extreme temperatures and limited rainfall. Despite the harsh climatic conditions, malaria transmission persists, primarily due to the presence of urban water sources such as ponds, reservoirs, and sewer systems. The city's diverse urban ecosystem offers a unique opportunity to study malaria vectors in a non-tropical environment. The proposed research was done in urban region of Bikaner city of Rajasthan, categorized into five urban areas: Eastern, Western, Northern, Southern, and Central zone. All these regions have varying population density, dwelling patterns, storage of water, and sanitation infrastructure.

2.2 Entomological Surveillance

Adult female *Anopheles* mosquitoes were collected during dusk and dawn using various methods, including aspirator tube, light traps, human landing catches, and animal baited traps. Anopheles mosquitoes were abundantly found in fresh water marshes, grassy ponds, bird water pots, cow water containers, ditches, near water leakage pipes, and small temporary rain pools. These were first collected and then transferred in sample collecting tubes.

Collections were made during peak malaria transmission seasons August 2022- July 2023 to maximize sample sizes.

Collection methods included hand catch and resting indoors. Density was calculated in terms of the number of mosquitoes per man hour. Identification of the species was done using standard taxonomic keys.

Species composition and abundance across regions were categorized using semi-quantitative indices (+, ++, +++).

2.3 Breeding Habitat Assessment

Mosquitoes and their larval stages were collected through the use of suction tubes and torches, as well as the dipping method for larval stages. In the laboratory, these specimens were carefully reared and identified using established standard taxonomic keys provided by Roy & Brown (2003). To collect mosquito larvae, we employed various techniques, such as using a plastic cup, pipette, or traditional dipper. When approaching larger containers like discarded tyres, we took care to minimize disturbance by swiftly immersing the cup at the water's surface instead of scooping water slowly. For smaller containers, we transferred the water to pans to facilitate the collection of immature stages. In cases where the openings of tyres and containers were too narrow, we utilized a pipette to extract the water.

Larval surveys were conducted in diverse urban habitats including:

- Puddles
- Cattle water points
- Pipe leakages
- Construction sites
- Household water storage containers
- Culverts
- Fodder rooms

Monthly occurrence and abundance of larvae were recorded for each *Anopheles* species.

2.4 Life Expectancy Studies

Adult longevity of *Anopheles* species was assessed under laboratory conditions during summer, monsoon, and winter seasons to evaluate survival potential relevant to parasite development. Collected specimens were maintained under controlled laboratory conditions to study life expectancy.

Temperature and humidity levels were regulated to simulate seasonal variations.

Species Identified: *Anopheles subpictus*, *Anopheles stephensi, Anopheles culicifacies* and *Anopheles annularis.*

Data Analysis: Life expectancy was calculated in days for both male and female mosquitoes across three seasons: summer, monsoon, and winter. The data was analysed to identify seasonal trends and gender-based differences

2.5 Malaria Case Data

Malaria cases for the years 2022 to 2024 were gathered from the PBM Hospital and other Govt. healthcare centres at Bikaner. It only comprised the laboratory-Confirmed malaria cases, as the diagnosis was done by the Peripheral blood smear test and Rapid Diagnosis Tests, as per the guidelines. Age and gender demographics were collected for each case to determine the population-wise distribution of malaria cases. Patients were categorized according to their age groups, and gender-based differences were observed regarding the burden of the disease. The year-wise analysis helped in understanding temporal trends in malaria incidence and provided a basis for correlating human malaria cases with vector density and seasonal transmission patterns in the urban areas of Bikaner city.

2.6 Data Analysis

Vector density data were analyzed in relation to seasonal malaria incidence to understand trends in disease transmission. Differences in the number of Anopheles vectors during various seasons were further compared with the number of reported malaria cases to determine the peak transmission seasons. Due to the ecological study, there was a need for mostly descriptive statistics. Based on the patterns, the relation between the abundance of the vector and malaria cases over the seasons and areas was deduced. This approach allowed meaningful interpretation of temporal and area-wise correlations, helping to explain the influence of vector dynamics on malaria transmission in the urban setting.

III.RESULTS

3.1 Species Composition and Regional Distribution

Four *Anopheles* species were recorded across all urban regions. *Anopheles stephensi* showed the highest abundance in Eastern and Northern regions (+++), followed by *An. subpictus* and *An. culicifacies* was moderately present, while *An. annularis* showed limited distribution, particularly absent in southern and central regions.

Table 1: Dominant *Anopheles* species and their urban distribution in Bikaner

Anopheles Species	Eastern	Western	Northern	Southern	Central	Urban Importance
Anopheles stephensi	+++	++	+++	+	++	Primary urban malaria vector
Anopheles subpictus	++	+	+++	+	++	Secondary vector
Anopheles culicifacies	++	+	++	+	+	Rural–urban interface vector
Anopheles annularis	+	+	+	NR	NR	Minor role

Note: + (0–50), ++ (50–100), +++ (>100), NR = Not recorded (Source: Entomological survey, Aug 2022–July 2023)

3.2 Seasonal Vector Density Patterns

Vector density peaked during monsoon (June–September) and early post-monsoon months. Northern and Eastern regions consistently showed higher densities, with *An. stephensi* exceeding (50 mosquitoes/man hour) during peak months. Winter months recorded the lowest densities across all regions.

Table 2: Seasonal trend of *Anopheles* vector density in urban Bikaner

Season	Vector Density	Dominant Species	Transmission Risk
Monsoon (July–Sep)	High	*An. stephensi* and *An. subpictus*	Very High
Post-monsoon (Oct)	Moderate–High	*An. stephensi*	High
Winter (Nov–Feb)	Low	*An. subpictus*	Low
Summer (May-June)	Moderate	*An. stephensi*	Moderate

3.3 Breeding Habitat Preference

Household water storage containers, culverts, and pipe leakages emerged as the most productive breeding habitats for *An. stephensi*. Construction sites and puddles supported mixed species breeding, especially during monsoon. Natural ponds were negligible contributors due to arid conditions.

Table 3: Major breeding habitats of *Anopheles stephensi* in urban areas

Breeding Habitat	Productivity	Remarks
Household water storage	High	Key urban breeding source
Culverts	High	Persistent water stagnation
Pipe leakages	Moderate–High	Common in older colonies

Construction sites	Moderate	Seasonal breeding
Puddles	Low–Moderate	Monsoon dependent

3.4 Adult Longevity and Transmission Potential

Anopheles stephensi exhibited the longest adult life span, particularly during winter and monsoon seasons (female longevity up to 25 days). This longevity is sufficient for completion of *Plasmodium* sporogony, enhancing transmission potential.

Table 4: Adult life expectancy of major female *Anopheles* species (Days)

Species	Summer female	Monsoon female	Winter female	Transmission Potential
An. stephensi	14.5	19.0	25.0	Very High
An. subpictus	13.0	20.0	23.5	High
An. culicifacies	12.0	20.5	21.5	Moderate
An. annularis	11.5	16.0	20.5	Low

3.5 Malaria Incidence Trends

Hospital data revealed higher malaria cases during and immediately after monsoon seasons, corresponding with peak vector densities. Adult males constituted the majority of cases, possibly due to occupational exposure and outdoor activities.

Table 5: Relationship between vector density and malaria incidence in Bikaner

Parameter	Observation
Peak mosquito density	Monsoon & post-monsoon
Peak malaria cases	Monsoon & post-monsoon
High-risk zones	Northern & Eastern Bikaner
Most affected group	Adult males
Key driver	High *An. stephensi* density

IV.DISCUSSION

The prevalence of *Anopheles stephensi* reinforces its status as a major vector of malaria in urban Bikaner. Despite low rainfall in Bikaner city and its surroundings does not limit vector breeding because of water storage in urban areas. The overall density of vectors in northern and eastern parts of Bikaner city could be due to high dwelling density and construction activities, along with improper management of water in these regions. The coincidence of vector density, longevity of adults, and incidence of malaria cases reinforces a positive correlation between vector density and incidence of malaria cases. These findings align with urban malaria patterns reported from other Indian cities but highlight unique desert-adapted transmission mechanisms.

V.CONCLUSION

Urban malaria transmission in the city of Bikaner is associated with the density of *Anopheles* vectors, especially *An. stephensi*, whose adaptability to the desert habitat allows for the persistence of the species even in areas that receive low rainfall.

Effective malaria control in desert cities must prioritize urban vector surveillance, management of household water storage, and targeted interventions during high-risk seasons.

VI.RECOMMENDATION

- Strengthen urban larval source management, focusing on household containers
- Regular surveillance during pre- and post-monsoon periods
- Community awareness programs on water storage hygiene
- Integration of entomological surveillance with hospital case data.

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