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A Study Of Species Composition And Seasonal Life Expectancy Of *Anopheles* Vectors Causing Malaria In And Around Urban Areas Of Bikaner City, Rajasthan.

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Abstract

The current study was based on species composition and seasonal life expectancy of Anopheles species responsible for the transmission of malaria in and around urban area of Bikaner, Rajasthan. Research was done with four dominant species: *Anopheles subpictus*, *Anopheles stephensi*, *Anopheles culicifacies* and *Anopheles annularis*, where their life expectancy has been examined in the laboratory conditions in summer, mon soon and winter seasons. Results have shown huge disparities in life span in the presence of seasonal and sexual influences, and generally female mosquitoes had longer life expectancies. The findings emphasize the need for season-specific vector control measures, with intensified surveillance and intervention during monsoon and winter seasons due to higher *Anopheles* mosquito longevity, thereby increasing the risk and outbreak of malaria transmission. Integrated vector management strategies should consider these seasonal patterns to optimize control efforts in and around urban area of Bikaner city, Rajasthan.

Keywords- *Anopheles*, malaria, species composition, life expectancy, vector, transmission.

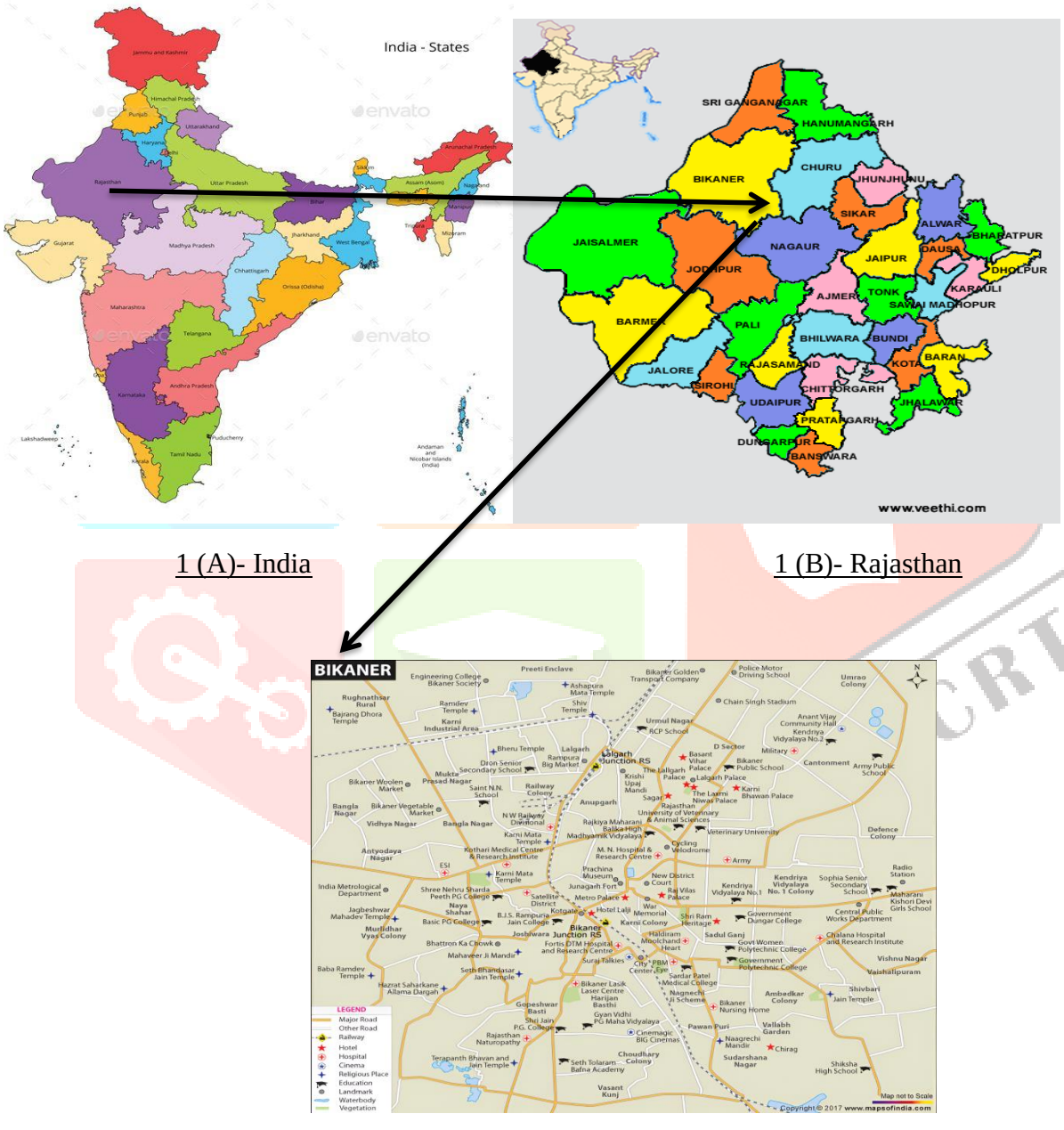
[I] Introduction

Malaria continues to be a major public health challenge in India. Malaria imposes great socio-economic burden on humanities. The climatic conditions including arid and semi-arid regions of Rajasthan, this weather favor *Anopheles* mosquitoes to flourish in studied area. Anopheles mosquitoes female are primary vectors for malaria that exhibit variations in species composition and life expectancy controlled by environmental and seasonal factors. Understanding these dynamics is necessary for formulation of strategies for effective vector control. "The dominant mosquito vectors of human malaria in India include *Anopheles culicifacies* and *Anopheles stephensi*, *Anopheles fluviatilis*, *Anopheles sundaicus* all adapting well to urban settings" (Dev & Sharma, 1995). This study deals with the species composition and life expectancy of some important Anopheles vectors in urban areas of Bikaner, characterized by extreme climatic conditions.

[II] Materials and Methods

Study Area:-

India is located in Asian continent. It lies in northern hemisphere and eastern hemisphere between latitudes 84' N and 37°6'N and longitude 68°7'E and 97°25'E. Rajasthan is located in India at north-western part it's latitude 23°3' and 30°12', north and longitudes 69°30' and 78°17' east while, Bikaner is located in north-west of Rajasthan. The research was conducted in and around urban Bikaner, at geographical coordinate 28.0271380° latitude and 73.302155° longitude and GPS coordinate *28° 1' 37.6968" N and 73° 18' 7.7580" E*. This area is known for its hot desert climate with extreme temperature fluctuations and minimal rainfall. This area was chosen based on high malaria incidence and diverse environmental conditions.



1 (A)- India

1 (B)- Rajasthan

1 (C)- Bikaner

Figure 1:- Represents the location of study area (A- India, B- Rajasthan, C- Bikaner)

Collection:-

Adult *Anopheles* mosquitoes were collected from different area in and around Bikaner city during dusk and dawn using various methods, including aspirator tube, CDC light traps placed at various location in urban area to trap indoor and outdoor mosquitoes, human landing catches (HLC), and animal baited traps. Anopheles mosquitoes were abundantly found in puddles, ponds, cattle's water points, pipe leakages, construction sites, house hold, Culverts, fodders room and temporary rain pools. These were first collected and then transferred in sample collecting tubes and brought alive to laboratory for further analysis. Collection was done during whole year to maximize sample size from August 2022- July 2023.

Life cycle-

Anopheles mosquitoes have four distinct phases: egg, larva, pupa and adult. Complete metamorphosis plays an important role in their development and survival in different environment conditions.

- Egg stage- Female *Anopheles* lays eggs on surface of stagnant water. Eggs are boat-shaped and under favorable temperature and humidity condition, hatch within 2-3 days.
- Larval Stage- Larva emerge and remains aquatic, larva rest parallel to water surface other than *Aedes* and *Culex* larva because *Anopheles* larva lack siphon tubes. These larvae feed on organic matter and microorganisms; this stage lasts up to 5-10 days, depending on food availability and temperature.
- Pupa stage- It is a transitional stage where larva transform into Adult. This is non-feeding stage but pupa remains active responding to disturbances by tumbling and flipping in water, stage lasts up to2-4 days.
- Adult stage- Adult female play a key role in malaria transmission by acting as vector for *Plasmodium* parasite casing malaria. The Adult life span varied in different season throughout year due to dynamic environmental conditions.

Understanding these phases is important for malaria vector control strategies, targeting different phase of life stages to reduce mosquito population effectively

Figure 2:- Illustrating the different phases of the *Anopheles* life cycle.

Laboratory conditions:-

Collected specimens were maintained under controlled laboratory conditions to study life expectancy. Temperature and humidity levels were regulated to simulate seasonal variations. Taxonomical key was used to identify the species composition. Identified species were then transferred into artificial chamber for further analysis of life expectancy.

Data Analysis:

Life expectancy was calculated in days for both male and female mosquitoes across three seasons: summer, monsoon, and winter. The data was analyzed to identify seasonal trends and sex based differences in *Anopheles* mosquitoes. Life expectancy was examined according to days survived by both the sexes during various seasons from August 2022 – July 2023.

[III] Results

Species Identified:

Four distinct species of *Anopheles* mosquitoes were identified in and around the urban area of Bikaner city, including :- (Plate-1) - *Anopheles stephensi*- Major urban vector, was found in high number near reservoirs, stagnant water sources.
(Plate-2) - *Anopheles subpictus*- Found in urban areas, near drainage system, artificial water bodies and temporary pool.
(Plate-3) - *Anopheles culicifacies*- Present primarily in area with agricultural activity on the outskirt of the city
(Plate-4) - *Anopheles annularis*- Noted to be present in both urban and rural settings, particularly near irrigation canals and vegetated water bodies.

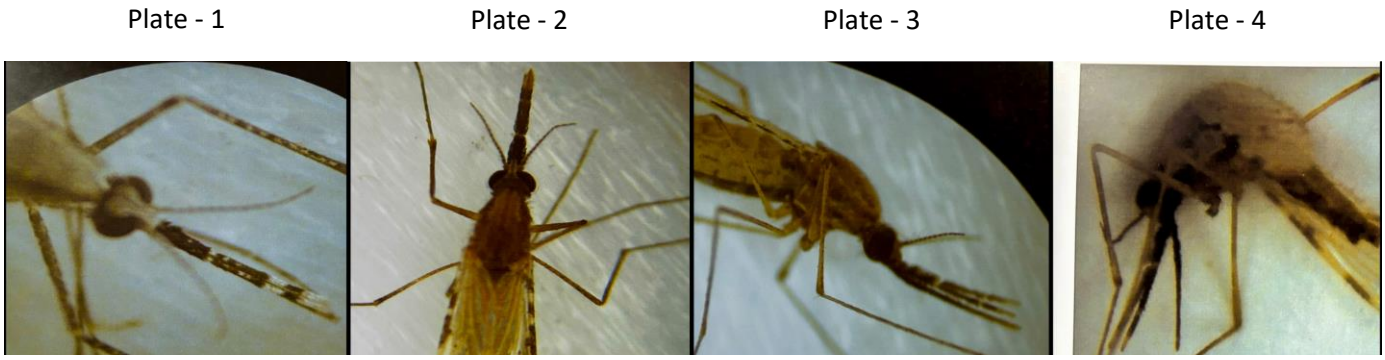


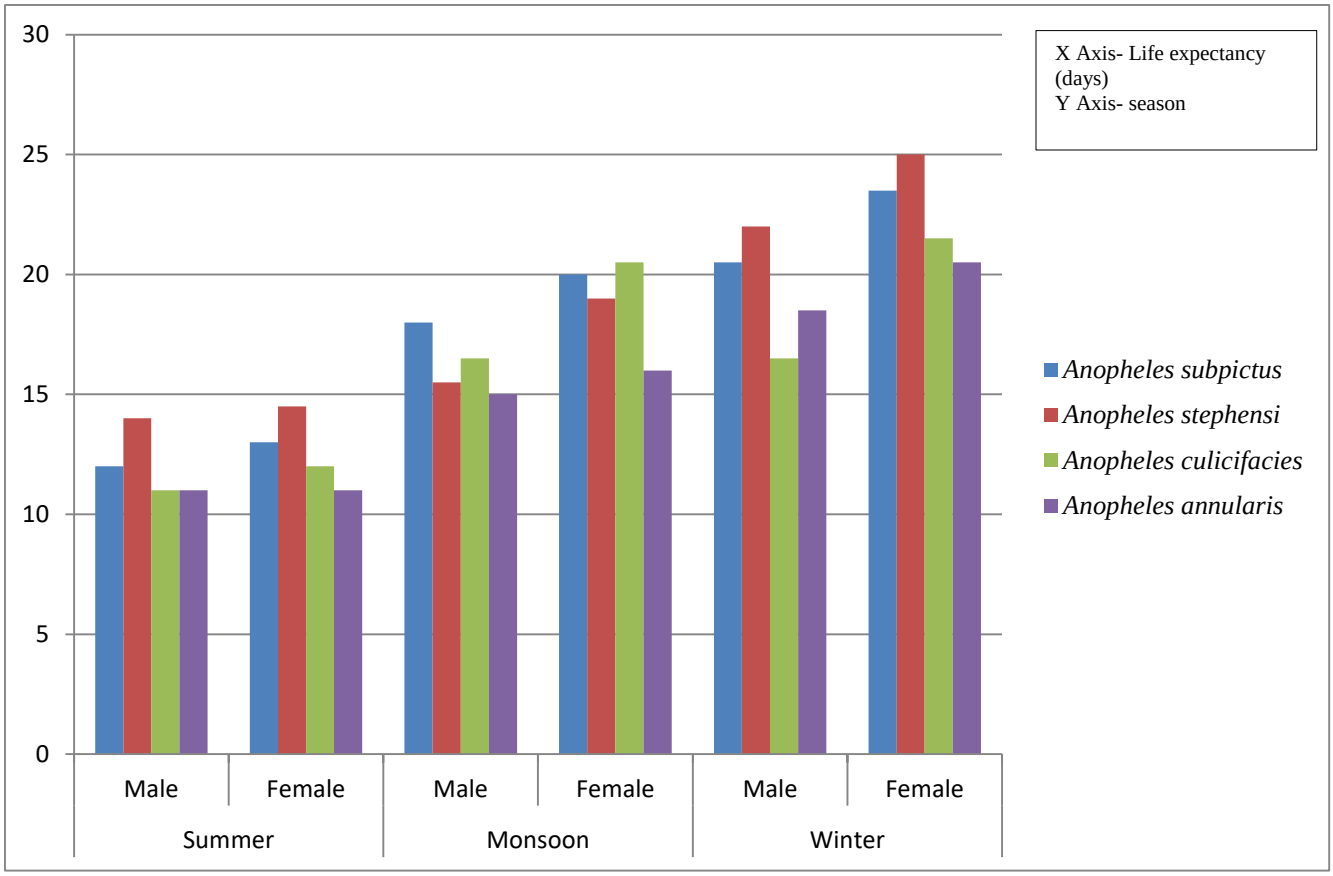
Figure 3- Representation of various plates showing species composition of different *Anopheles* species

Species composition of various *Anopheles* species recorded at study area during the study period from (August 2022 – July 2023):- The study revealed the dominance of *Anopheles stephensi* in urban areas, followed by *Anopheles subpictus*, *Anopheles culicifacies*, and *Anopheles annularis*. The prevalence of species varied with environmental conditions, particularly due to rainfall, temperature and humidity and other environmental factors.

Table1:- Trends of life expectancy in adult *Anopheles* species (days) under laboratory condition.

	Summer		Monsoon		Winter	
Species composition	Male	Female	Male	Female	Male	Female
Anopheles subpictus	10-13 (12.00)	12-14 (13.00)	17-19 (18.00)	18-22 (20.00)	19-22 (20.50)	22-25 (23.50)
Anopheles stephensi	13-15 (14.00)	13-16 (14.50)	14-17 (15.50)	18-20 (19.00)	21-23 (22.00)	23-27 (25.00)
Anopheles culicifacies	10-12 (11.00)	11-13 (12.00)	16-17 (16.50)	19-22 (20.50)	16-17 (16.50)	21-22 (21.50)
Anopheles annularis	10-12 (11.00)	10-13 (11.00)	14-16 (15.00)	15-17 (16.00)	17-20 (18.50)	18-23 (20.50)

Graph 1:- Representing life expectancy of *Anopheles* species (Laboratory conditions)



Summer Season:

- *Anopheles stephensi* (Female): Highest life expectancy (~14.5 days)
- *Anopheles annularis* (Male): Lowest life expectancy (~11 days)

The relatively lower life expectancy of mosquitoes, particularly *Anopheles annularis* (Male) (~11 days), suggests that high temperatures and potentially lower humidity levels create harsher conditions, leading to increased mortality. *Anopheles stephensi* (Female) exhibits the highest longevity (~14.5 days), possibly due to better adaptability to warm urban environments where water sources are available.

Monsoon Season:

- *Anopheles stephensi* (Female): ~19 days
- *Anopheles culicifacies* (Female): ~20.5 days

A notable increase in life expectancy across all species suggests that abundant water availability and high humidity create ideal breeding sites and survival conditions. *Anopheles stephensi* (Female) (~19 days) and *Anopheles culicifacies* (Female) (~20.5 days) show significant longevity, which may contribute to a higher risk of malaria transmission during this season.

Winter Season:

Peak life expectancy observed, especially in female mosquitoes.

- *Anopheles stephensi* (Female): Up to 25 days
- *Anopheles annularis* (Female): ~20.5 days

The highest life expectancy values are recorded, particularly in females, with *Anopheles stephensi* (Female) living up to 25 days and *Anopheles annularis* (Female) (~20.5 days). Lower temperatures may slow metabolic rates, reducing energy expenditure and prolonging lifespan. The extended lifespan in winter increases the likelihood of mosquitoes surviving long enough to complete multiple gonotrophic cycles, potentially sustaining disease transmission even in winter months.

[IV] Discussion

It is noted that the life expectancy of *Anopheles* species varies significantly according to seasons. "Mild temperatures and reduced evaporation stress during winter favor longer survival, while extreme summer heat limits the lifespan of mosquitoes" (Kumar & Sharma: 2021). "Species composition varies significantly between urban and rural areas due to environmental differences" (Charan & Saxena, 2022).
In addition, there are biological factors associated with reproduction due to which females constantly outlive the males.
It is reflective of the fact that *An. stephensi* being recognized for their ability to survive in urban areas has been targeted for malaria control in Bikaner. "*Anopheles stephensi,* adapts well to urban environmental conditions has resulted in its enhanced role in the malaria transmission in India." (Singh *et al.* 2023). "The wild and colonized *An. stephensi* were roughly equally susceptible to oocyst stage *Plasmodium* infection causing malaria infection." (Mohanty *et al.* 2018).
It underlines that climatic factors are playing a critical role in the dynamics of the vectors th at may pose great implications in controlling malaria in arid regions such as Bikaner. (Sarkar, S., *et al.* 2019). A high proportion of human blood meals among female Anopheles mosquitoes in Bikaner urban areas indicate a high risk for malaria transmission. The high human density with fewer alternative hosts in the urban areas enhances the opportunities for contact between humans and vectors, resulting in potential outbreaks. (Swami N., *et al.* 2024). The prolonged life expectancy during winter may extend the malaria transmission window, emphasizing the need for year-round vector surveillance.

[V] Conclusion

This research highlights the dynamic nature of *Anopheles* species composition and life expectancy in Bikaner. Seasonal variations significantly impact on vector longevity, influencing urban malaria transmission risks. Seasonal variations in the life expectancy of *Anopheles* mosquitoes, shows a clear trend of increased longevity in monsoon and winter seasons due to favorable environmental conditions. The winter season exhibits the highest life expectancy, particularly for females. These findings emphasize the need for season-specific vector control measures, with intensified surveillance and intervention during monsoon and winter seasons when mosquito longevity is higher, thereby increasing the risk of malaria transmission. Integrated vector management strategies should consider these seasonal patterns to optimize control efforts in and around urban area of Bikaner city, Rajasthan. "Understanding vector biology in specific ecological contexts is essential for effective malaria control" (Swami & Srivastava, 2012).

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