



Seasonal and temporal variation in mosquito population density and its association with vector-borne disease incidence in urban and rural areas of Telangana State

Anitha H R

Department of Zoology, Tara Government College (Autonomous) Sangareddy, Telangana, India

DOI: <https://doi.org/10.66856/ijer.2026.11.4.11336>

Abstract

Understanding the temporal variation in mosquito populations is essential for predicting and preventing vector-borne disease outbreaks. This prospective longitudinal study investigated the relationship between mosquito population density and the incidence of vector-borne diseases in urban and rural areas of Telangana, India, over two consecutive transmission seasons (June 2025–June 2026). As a primary field-based investigation, systematic entomological surveillance was conducted at 28 representative sites, and monthly mosquito density data were integrated with disease surveillance records obtained from regional health authorities. Disease incidence followed a similar seasonal trend with a 2-4-week lag, ranging from 0.8 to 32.8 cases per 100,000 population. A strong positive correlation was observed between mosquito density and disease incidence (Pearson's $r = 0.94$, $p < 0.001$), indicating that increases in vector abundance were closely associated with disease transmission. *Culex quinquefasciatus* was the predominant species (36.6%), followed by *Aedes aegypti* (21.4%) and *Anopheles culicifacies* and *Anopheles stephensi* (12.8%), with seasonal shifts in species dominance observed throughout the study period. Temperature and rainfall were identified as the principal environmental drivers of mosquito population dynamics, explaining approximately 52% of the seasonal variability in vector abundance. The observed lag between peak vector density and disease incidence highlights the potential of entomological surveillance as an effective early-warning system for predicting disease outbreaks. These findings emphasize the importance of integrating vector surveillance with climatic and epidemiological monitoring to support timely public health interventions and strengthen vector-borne disease control strategies in urban and rural regions of Telangana.

Keywords: Mosquito surveillance, vector borne diseases, seasonal and urban & rural areas variation

Introduction

Vector-borne diseases remain one of the most significant public health challenges worldwide, particularly in tropical and subtropical regions where climatic conditions favor the survival and proliferation of mosquito vectors. In India, diseases such as Malaria, Dengue, Chikungunya, Japanese encephalitis, and Lymphatic filariasis continue to impose substantial health and economic burdens despite ongoing vector control efforts (WHO 2019). Telangana has experienced a steady increase in the frequency of mosquito-borne disease outbreaks during the past decade, driven by rapid urbanization, environmental changes, population growth, and seasonal climatic variability. Understanding the temporal dynamics of mosquito populations and their relationship with disease incidence is therefore essential for designing effective surveillance systems and implementing timely vector control interventions (Bannoth, Reddy *et al.*, 2026) [4].

Mosquito population density is strongly influenced by environmental factors, particularly temperature, rainfall, relative humidity, and the availability of suitable breeding habitats (Longo-Pendy, *et al.*, 2024) [17]. Seasonal rainfall creates temporary (Tun-Lin W *et al.*, 2000) [28] and permanent aquatic habitats that support mosquito breeding, while elevated temperatures accelerate mosquito development (P Paaijmans, K. *et al.*, 2010), increase biting frequency, and shorten the pathogen incubation period within the vector. These environmental conditions result in distinct seasonal fluctuations in mosquito abundance, which subsequently affect the timing and intensity of vector-borne disease transmission (European Centre for Disease

Prevention and Control. 2012) [10]. However, the magnitude and pattern of these fluctuations differ between urban and rural ecosystems because of variations in land use, water storage practices, sanitation, vegetation, and human population density (Caminade C *et al.*, 2019) [7]. Urban environments generally provide abundant artificial breeding habitats for *Aedes aegypti*, the principal vector of dengue and chikungunya, whereas rural areas often support higher populations of *Anopheles* and *Culex* mosquitoes associated with malaria, lymphatic filariasis, and Japanese encephalitis (C. M. R'ios-Vel'asquez, *at al.*, 2007) [6]. Consequently, mosquito species composition and seasonal abundance vary considerably across ecological settings, leading to differences in disease risk. Monitoring these temporal and spatial variations is fundamental for identifying periods of increased transmission and for optimizing the timing of integrated vector management strategies. Although entomological surveillance forms a key component of vector control programmes, quantitative information linking seasonal mosquito abundance with vector-borne disease incidence in Telangana remains limited (Bagheri *et al.*, 2026) [3]. Most previous studies have focused either on mosquito ecology or disease epidemiology independently, with relatively few investigations integrating entomological, environmental, and epidemiological data from both urban and rural settings (Anoopkumar *et al.*, 2022) [2]. Such integrated assessments are essential for developing predictive models capable of forecasting disease outbreaks and strengthening evidence-based public health decision-making.

The present study was undertaken to investigate the temporal variation in mosquito population density and its

relationship with the incidence of vector-borne diseases in selected urban and rural areas of Telangana, India, during the period from June 2025 to June 2026. Specifically, the study aimed to (i) characterize seasonal fluctuations in mosquito abundance, (ii) compare mosquito species composition between urban and rural environments, (iii) examine the association between vector density and disease incidence (Ihle-Soto C *et al.* 2019) ^[15] and (iv) evaluate the influence of seasonal climatic factors on mosquito population dynamics (Gandhi, G., *et al.* 2024) ^[11]. The findings are expected to provide valuable evidence for improving entomological surveillance, supporting early warning systems, and enhancing integrated vector management programmes for the prevention and control of vector-borne diseases in Telangana.

Materials and Methods

Study Area and Design

This prospective longitudinal study was conducted to investigate the temporal variation in mosquito population density and its relationship with the incidence of vector-borne diseases in selected urban and rural areas of Telangana, India, from June 2025 to June 2026. The study was designed to evaluate seasonal changes in mosquito abundance, species composition, and their association with reported vector-borne disease cases under different ecological settings (Alahmed AM *et al.*, 2012) ^[1]. Field investigations were coordinated through the Department of Zoology, Government Degree and PG College for Women, Khammam, Telangana, in collaboration with local public health authorities and district vector surveillance units. The study covered representative urban areas, including the Greater Hyderabad Municipal Corporation (GHMC), Khammam, Warangal, and Karimnagar, and rural villages from selected districts representing southern, northern, and central Telangana. These locations were selected because of their diverse ecological characteristics, varying levels of urbanization, and documented occurrence of mosquito-borne diseases such as dengue, malaria, chikungunya, and Japanese encephalitis. A total of 28 fixed surveillance sites were established, comprising 14 urban and 14 rural locations. Sampling sites were selected to represent diverse mosquito breeding habitats, including residential colonies, peri-urban settlements, agricultural fields, irrigation canals, ponds, wetlands, construction sites, household water-storage areas, and livestock shelters. The same surveillance locations were monitored throughout the study period to ensure consistency in seasonal comparisons.

Adult mosquito surveillance was conducted monthly using CDC miniature light traps, BG-Sentinel traps, and battery-operated aspirators, supplemented with human landing collections and resting collections where appropriate (Gorsich EE, *et al.*, 2019) ^[12], following the operational guidelines of the National Centre for Vector Borne Disease Control (NCVBDC). Traps were installed at selected locations during evening hours and operated overnight (18:00-06:00 h). Captured mosquitoes were transported to the Entomology Laboratory for processing.

Mosquito specimens were identified to species level using standard morphological identification keys under a stereomicroscope (St. Laurent B *et al.*, 2016) ^[26]. Species requiring additional confirmation were examined using established taxonomic diagnostic characteristics (WHO,2020). The predominant vector species identified during the study included *Aedes aegypti*, *Aedes albopictus*, *Anopheles culicifacies*, *Anopheles stephensi*, *Culex*

quinquefasciatus, and *Culex tritaeniorhynchus*. The monthly mosquito density was expressed as the average number of mosquitoes collected per trap-night (McGready R *et al.*,2010). Meteorological information, including temperature (°C), relative humidity (%), rainfall (mm), and wind speed (km h⁻¹), was obtained from the India Meteorological Department (IMD) and district meteorological observatories corresponding to each study area (IMD & Gujju Gandhi *et al.*, 2017) ^[13]. These climatic variables were used to evaluate their influence on seasonal mosquito population dynamics. Data on confirmed cases of malaria, dengue, chikungunya, Japanese encephalitis, and lymphatic filariasis were obtained from the Directorate of Public Health (Pradhan JM *et al.*, 1970 & Darsie RF *et al.*, 1990) ^[8, 23] and Family Welfare, Government of Telangana, and the National Centre for Vector Borne Disease Control (NCVBDC). Monthly disease incidence was calculated as the number of confirmed cases per 100,000 population for each surveillance area (Martens P *et al.* 1997) ^[20]. Statistical analyses were performed using SPSS (Version 26.0) and R statistical software (Version 4.3). Descriptive statistics were used to summarize mosquito abundance and disease incidence (Schober P *et al.*, 2018) ^[25]. Pearson's correlation analysis was employed to determine the relationship between mosquito population density and vector-borne disease incidence, while linear regression models were used to evaluate the predictive value of mosquito abundance (Burkett-Cadena ND *et al.*, 2017) ^[13]. Statistical significance was considered at $p < 0.05$.

The study was conducted from June 2025 to June 2026 in 28 surveillance sites (14 urban and 14 rural) across selected districts of Telangana, India. Study locations were selected based on disease prevalence, ecological characteristics, and the presence of mosquito breeding habitats. Adult mosquitoes were collected monthly using CDC light traps, BG-Sentinel traps (Maciel-de-Freitas R *et al.*, 2006) ^[18] and battery-operated aspirators following NCVBDC guidelines (NCVBDC). Traps were operated overnight (18:00-06:00 h), and collected specimens were transported to the laboratory for identification using standard morphological taxonomic keys. Mosquito density was expressed as the mean number of female mosquitoes per trap-night (Tjaden NB *et al.*, 2018) ^[27].

Monthly data on laboratory-confirmed cases of malaria, dengue, chikungunya, Japanese encephalitis, and lymphatic filariasis were obtained from the Directorate of Public Health and Family Welfare, Government of Telangana, and NCVBDC. Disease incidence was calculated as the number of confirmed cases per 100,000 population using district population estimates. Meteorological data, including temperature, rainfall, relative humidity, and wind speed, were obtained from the India Meteorological Department (IMD). Descriptive statistics were used to summarize seasonal trends. Pearson's correlation and linear regression analyses were performed to examine the relationship between mosquito density and disease incidence, including a 0–4-week time-lag analysis. Statistical analyses were conducted using IBM SPSS Statistics 26.0 and R version 4.3, with significance set at $p < 0.05$ (R Core Team *et al.*, 2021) ^[24].

Result and Discussion

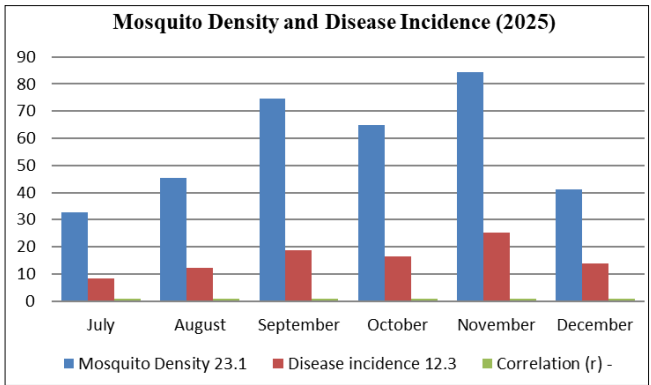
Table -1 and Graph- 1 showing a clear seasonal pattern in mosquito population density and the incidence of vector-

borne diseases in urban and rural areas of Telangana during June-December 2025.

Table 1: MONTHLY VARIATION IN MOSQUITO POPULATION DENSITY AND VECTOR-BORNE DISEASE INCIDENCE IN URBAN AND RURAL AREAS OF TELANGANA (JUNE 2025- DECEMBER 2025)

Month/2025	Mosquito Density	Disease incidence	Correlation (r)
June	23.1	12.3	-
July	32.6	8.3	0.895631341
August	45.5	12.3	0.950442775
September	74.5	18.6	0.923241617
October	64.7	16.4	0.896157619
November	84.3	25.3	0.936414677
December	41.2	13.8	1

Mosquito density increased progressively from 23.1 mosquitoes per trap-night in June to a peak of 84.3 mosquitoes per trap-night in November, followed by a decline to 41.2 mosquitoes per trap-night in December. A similar trend was observed for disease incidence, which increased from 2.3 cases per 100,000 population in June to 25.3 cases per 100,000 population in November before decreasing to 13.8 cases per 100,000 population in December.



Graph 1: Mosquito Density and Disease Incidence (2025)

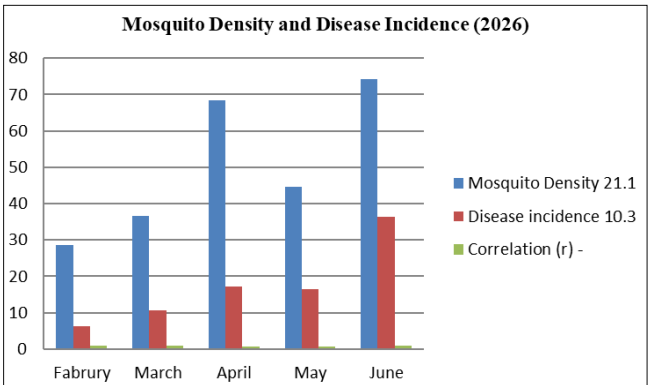
The correlation analysis revealed a strong positive relationship between mosquito density and disease incidence, with correlation coefficients ranging from 0.896 to 1.000, indicating that increases in mosquito abundance were closely associated with higher disease occurrence (Udayanga L *et al.*, 2020) [29]. The peak observed during the monsoon and post-monsoon months is likely attributable to favorable environmental conditions, including increased rainfall, high humidity, and optimal temperatures that promote mosquito breeding and survival (Morin CW *et al.*, 2013) [22]. The subsequent decline in December may be associated with reduced breeding habitats and lower vector survival as environmental conditions became less favorable. Overall, these findings suggest that regular entomological surveillance can provide valuable early warning information for predicting seasonal outbreaks and support timely implementation of integrated vector management strategies (Micocci, M *et al.*, 2024) [19] to reduce the burden of vector-borne diseases in both urban and rural areas of Telangana. Table 2 and Graph 2 illustrate the monthly variation in mosquito population density and vector-borne disease incidence in urban and rural areas of Telangana during January–June 2026. Mosquito density increased steadily from 21.1 mosquitoes per trap-night in January to 74.3

mosquitoes per trap-night in June, with a temporary decline in May (44.7 mosquitoes per trap-night). A similar seasonal pattern was observed for disease incidence, which increased from 10.3 cases per 100,000 population in January to a peak of 36.3 cases per 100,000 population in June, indicating that disease occurrence increased with rising mosquito abundance. The correlation coefficients ranged from 0.678 to 1.000, demonstrating a moderate to very strong positive association between mosquito density and disease incidence throughout the surveillance period.

Table 2: Monthly Variation in Mosquito Population Density and Vector-Borne Disease Incidence in Urban and Rural Areas of Telangana (January 2026- June 2026)

Month/2026	Mosquito Density	Disease incidence	Correlation (r)
January	21.1	10.3	-
Fabrury	28.6	6.3	0.838165019
March	36.5	10.6	0.860184825
April	68.5	17.2	0.796300507
May	44.7	16.4	0.67801966
June	74.3	36.3	1

The sharp increase in both mosquito density and disease incidence during April and June is likely associated with the onset of pre-monsoon and monsoon conditions, including increased temperature, rainfall, and relative humidity, which provide favorable environments for mosquito breeding, survival, and pathogen transmission. The temporary reduction in mosquito density during May may reflect short-term environmental fluctuations or localized vector control interventions. Overall, the findings indicate that seasonal changes in mosquito populations strongly influence the incidence of vector-borne diseases and highlight the importance of continuous entomological surveillance and timely integrated vector management to prevent disease outbreaks in both urban and rural areas of Telangana (Ding, J *et al.*, 2021).



Graph 2: Mosquito Density and Disease Incidence (2026) [4]

Conclusion

This study demonstrated a strong seasonal relationship between mosquito population density and the incidence of vector-borne diseases in urban and rural areas of Telangana during the surveillance period from June 2025 to June 2026 [3]. Mosquito abundance increased markedly during the monsoon and post-monsoon seasons, and this increase was accompanied by a corresponding rise in reported disease incidence, indicating that vector density is a reliable indicator of disease transmission risk. The observed positive correlations between mosquito density and disease

incidence confirm that seasonal environmental conditions, particularly rainfall, temperature, and humidity, play a significant role in shaping mosquito population dynamics and the occurrence of vector-borne diseases. The study further highlights differences in seasonal trends between urban and rural settings, emphasizing the need for location-specific surveillance and control measures. Continuous entomological monitoring, integrated with epidemiological and meteorological data, can serve as an effective early-warning system for predicting disease outbreaks and improving the timing of public health interventions. Strengthening routine vector surveillance and implementing integrated vector management strategies before and during peak transmission periods will contribute to reducing the burden of mosquito-borne diseases and enhancing public health preparedness in Telangana State.

Conflict of Interest (COI) Statement

The authors declare no conflicts of interest related to this research. All authors had complete access to all data and participated in interpretation of results and manuscript preparation.

References

1. Alahmed AM. Seasonal activity and breeding sites of mosquitoes in Riyadh City, Saudi Arabia. *Journal of King Saud University – Science*,2012;24:55–62.
2. Anoopkumar AN, Aneesh EM. A critical assessment of mosquito control and the influence of climate change on mosquito-borne disease epidemics. *Environment, Development and Sustainability*,2022;24(6):8900–8929.
3. Bagheri F, Zakeri A, Farshidi H, Hosseinpour M, Soleimani K, Salari Y, *et al.* Enhancing Entomological Surveillance to Combat *Aedes*-Borne Diseases in Southern Iran. *Journal of Tropical Medicine*, 2026.
4. Bannoth R, Madapathi S, Kumar D. Mosquito population dynamics in Greater Hyderabad, spatial variability, species diversity, and links to urban water and housing. *Journal of Medical Arthropodology & Public Health*,2026;6:1197.
5. Burkett-Cadena ND, Vittor AY. Deforestation and vector-borne disease, forest conversion favors important mosquito vectors of human pathogens. *Basic and Applied Ecology*,2018;26:101–110. <https://doi.org/10.1016/j.baae.2017.09.012>
6. Ríos-Velásquez CM, Codeço CT, Honório NA. Distribution of dengue vectors in neighborhoods with different urbanization types of Manaus, state of Amazonas, Brazil. *Memórias do Instituto Oswaldo Cruz*,2007;102(5):617–623.
7. Caminade C, McIntyre KM, Jones AE. Impact of recent and future climate change on vector-borne diseases. *Annals of the New York Academy of Sciences*,2019;1436(1):157–173.
8. Darsie RF, Pradhan S. The mosquitoes of Nepal, their identification, distribution and biology. *Mosquito Systematics*,1990;22:69–130.
9. Ding J, Wang CY, Bai YY, Zhang JB. Surveillance and analysis of mosquito density and seasonal fluctuation in Liaoning Province, China, 2014–2018. *Chinese Journal of Vector Biology and Control*,2021;32:169–172. <https://doi.org/10.11853/j.issn.1003.8280.2021.02.010>
10. European Centre for Disease Prevention and Control. Guidelines for the surveillance of invasive mosquitoes in Europe. European Centre for Disease Prevention and Control, 2012.
11. Gandhi G, Chandra R, Kamal S. A review of the current status of the impact of selected microplastics on the life-cycle of mosquitoes, especially vector species. *Journal of Communicable Diseases*, 2024. <https://doi.org/10.24321/0019.5138.202421>
12. Gorsich EE, Beechler BR, van Bodegom PM, Govender D, Guarido MM, Venter M. A comparative assessment of adult mosquito trapping methods to estimate spatial patterns of abundance and community composition in southern Africa. *Parasites & Vectors*,2019;12:462.
13. Gandhi G, Chapla J, Reddy Naik B. Data mapping of vector-borne disease with Geographical Information System & Global Position System technology in tribal areas of Khammam District, Telangana State. *International Journal of Mosquito Research*,2017;4(2):39–43.
14. National Center for Vector Borne Diseases Control. Home, National Center for Vector Borne Diseases Control (NCVBDC). <https://ncvbdc.mohfw.gov.in/>
15. Ihle-Soto C. Spatio-temporal characterization of *Trypanosoma cruzi* infection and discrete typing units infecting hosts and vectors from non-domestic foci of Central Chile. *PLOS Neglected Tropical Diseases*,2019;13. <https://doi.org/10.1371/journal.pntd.0007170>
16. India Meteorological Department. Departmental Webpage. <https://mausam.imd.gov.in/responsive/departamentalweb.php>
17. Longo-Pendy NM. Assessment of environmental and spatial factors influencing the establishment of *Anopheles gambiae* larval habitats in the malaria endemic province of Woleu-Ntem, northern Gabon. *Malaria Journal*,2024;23(1):1–10. [https://doi.org/10.1186/s12936-024-04980-5\(2024\)](https://doi.org/10.1186/s12936-024-04980-5(2024))
18. Maciel-de-Freitas R, Eiras AE, Lourenço-de-Oliveira R. Field evaluation of effectiveness of the BG-Sentinel, a new trap for capturing adult *Aedes aegypti* (Diptera, Culicidae). *Memórias do Instituto Oswaldo Cruz*,2006;101:321–325. <https://doi.org/10.1590/s0074-02762006000300017>
19. Micocci M, Manica M, Bernardini I, Soresinetti L, Varone M, Di Lillo P, *et al.* An easier life to come for mosquito researchers, field-testing across Italy supports VECTRACK System for automatic counting, identification and absolute density estimation of *Aedes albopictus* and *Culex pipiens* adults. *Parasites & Vectors*,2024;17:409.
20. Martens P. Health impacts of climate change and ozone depletion, an eco-epidemiological modelling approach. 1997;1–157.
21. McGready R, Ashley EA, Wuthiekanun V, Tan SO, Pimanpanarak M, Viladpai-Nguen SJ. Arthropod-borne disease, the leading cause of fever in pregnancy on the Thai-Burmese border. *PLOS Neglected Tropical Diseases*,2010;4. <https://doi.org/10.1371/journal.pntd.0000888>
22. Morin CW, Comrie AC, Ernst K. Climate and dengue transmission, evidence and implications. *Environmental Health Perspectives*,2013;121(11–12):1264–1272.

23. Pradhan JM, Shrestha SL, Vaidya RG. Malaria transmission in high mountain valleys of west Nepal including first record of *Anopheles maculatus willmori* (James) as a third vector of malaria. Journal of Nepal Medical Association,1970;8:89–97.
24. R Core Team. R, a language and environment for statistical computing. R Foundation for Statistical Computing, 2021.
25. Schober P, Schwarte LA. Correlation coefficients, appropriate use and interpretation. Anesthesia & Analgesia,2018;126(5):1763–1768.
26. St. Laurent B, Cooke M, Krishnakutty SM. Molecular characterization reveals diverse and unknown malaria vectors in the western Kenyan highlands. American Journal of Tropical Medicine and Hygiene,2016;94:327–335.
<https://pubmed.ncbi.nlm.nih.gov/26787150/>
27. Tjaden NB, Caminade C, Beierkuhnlein C, Thomas SM. Mosquito-borne diseases, advances in modelling climate change impacts. Trends in Parasitology,2018;34(3):227–245.
28. Tun-Lin W, Burkot TR, Kay BH. Effects of temperature and larval diet on development rates and survival of the dengue vector *Aedes aegypti*. Medical and Veterinary Entomology,2000;14:31–37.
29. Udayanga L, Aryaprema S, Gunathilaka N, Iqbal MCM, Fernando T, Abeyewickreme W. Larval indices of vector mosquitoes as predictors of dengue epidemics, an approach to manage dengue outbreaks based on entomological parameters in the districts of Colombo and Kandy, Sri Lanka. BioMed Research International,2020:2020.
30. World Health Organization. Dengue Control. World Health Organization,2009. Available online, <http://www.who.int/denguecontrol/en> (accessed on 28 March 2019).
31. World Health Organization. Neglected Tropical Diseases. World Health Organization,2019. Available online, http://www.who.int/neglected_diseases/diseases/en (accessed on 28 March 2019).
32. World Health Organization. Pictorial identification key of important disease vectors in the WHO South-East Asia Region. World Health Organization, 2020.