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Ecological Assessment of *Culex* Mosquitoes and Their Public Health Significance in Aligarh District

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Abstract

Culex mosquitoes are significant carriers of various mosquito-borne diseases, presenting serious public health issues in northern India. This review takes a closer look at *Culex* mosquitoes in the Aligarh district of Uttar Pradesh, examining their distribution, the variety of habitats they occupy, their feeding habits, and their impact on public health. The district's subtropical climate, widespread agricultural activities, polluted water sources, and poor sanitation create ideal conditions for these mosquitoes to thrive. *Culex* species are found in a range of larval environments, such as sewage drains, stagnant ponds, irrigation channels, and septic tanks. Their nighttime feeding habits and opportunistic nature contribute to the spread of diseases like lymphatic filariasis and Japanese encephalitis. The review also points out how water quality affects mosquito breeding and stresses the importance of integrated vector management as a sustainable control strategy. Grasping the local ecological dynamics is crucial for minimizing the risks associated with mosquito-borne diseases.

Keywords: *Culex* mosquitoes, Ecological distribution, Larval breeding habitats, Public health significance

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Introduction

Mosquitoes are among the most crucial arthropod vectors that affect human health worldwide, transmitting a variety of pathogens that lead to significant illness and death. In tropical and subtropical regions, the *Culex* genus plays a vital role in spreading several parasitic and viral diseases, which is a major concern for public health officials. India, with its diverse climate, rapid urbanization, and varying sanitation levels, creates ideal conditions for *Culex* mosquitoes to thrive. Uttar Pradesh, in particular, is especially at risk for mosquito-borne diseases, with districts like Aligarh facing ongoing health challenges related to these vectors. *Culex* mosquitoes are quite adaptable and tend to favor breeding in water that's polluted and rich in organic matter, like sewage drains, stagnant ponds, septic tanks, and irrigation channels. This ability to thrive in various environments allows them to flourish in urban, peri-urban, and rural areas alike (Service, 2012). In Aligarh district, with its mix of land uses, dense human populations, agricultural activities, and poor drainage systems, the conditions are just right for *Culex* mosquitoes to multiply. The seasonal monsoon rains also boost the number of places where larvae can develop, leading to rapid population growth and a higher risk of disease transmission. From a public health angle, *Culex* mosquitoes are crucial as they transmit various diseases, including lymphatic filariasis, *Japanese encephalitis*, West Nile virus, and other arboviral infections. *Culex* quinquefasciatus is the main vector for *Wuchereria bancrofti*, which causes lymphatic filariasis a chronic and debilitating disease that impacts millions of people in India (WHO, 2020). Furthermore, members of the *Culex vishnui* group are linked to the spread of Japanese encephalitis, a serious viral illness with high fatality rates, particularly among children in rural and peri-urban settings (Solomon *et al*., 2003). The nocturnal feeding habits and human-biting preferences of *Culex* mosquitoes only increase the risk. The ecological assessment of *Culex* mosquitoes involves examining where they are found, their breeding habitats, how their populations fluctuate with the seasons, and their interactions with both environmental and human factors. Such assessments are key to understanding the dynamics of mosquito populations and creating effective control and prevention strategies (Becker *et al*., 2020). In regions like Aligarh, where socio-economic inequalities and environmental degradation are present, these ecological studies offer important insights into how human activities shape mosquito ecology and the spread of diseases. Even though we know how important *Culex* mosquitoes are, there's still a lack of localized ecological data from the Aligarh district. To really get a handle on what drives mosquito populations and the health risks they bring, we need a thorough review of the existing ecological and public health information. By understanding how *Culex* mosquitoes interact with their local environment, we can develop better strategies for managing these pests and ultimately improve public health. This review zeroes in on the ecological assessment of *Culex* mosquitoes in Aligarh district, emphasizing their role in public health and disease prevention.

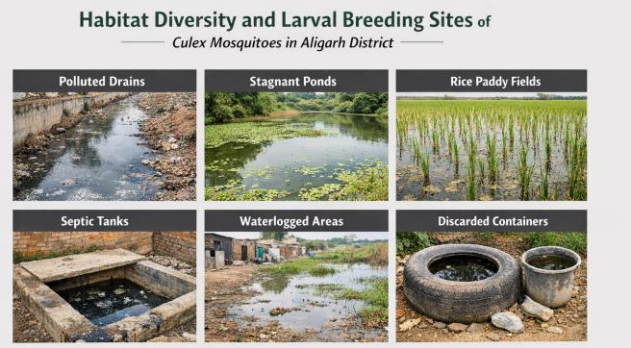
Ecological Distribution of *Culex* Mosquitoes in Aligarh District

The ecological spread of *Culex* mosquitoes in Aligarh district is significantly shaped by local environmental factors, land usage, and human activities. Aligarh, found in the upper Gangetic plains of Uttar Pradesh, enjoys a subtropical climate with hot summers, monsoon rains, and mild winters, which are all conducive to the survival and reproduction of mosquitoes. The district is a mix of urban hubs, peri-urban areas, agricultural fields, wetlands, ponds, canals, and a wide network of drainage, offering a variety of ecological niches for *Culex* species to flourish. *Culex* quinquefasciatus is the most widely spread species in the district, mainly found in polluted and nutrient-rich water bodies like open sewage drains, septic tanks, stagnant ponds, and wastewater areas close to residential neighborhoods. Its impressive tolerance for poor water quality helps it thrive in urban and semi-urban environments (Kumar *et al*., 2021). In contrast, the *Culex* vishnui group, which includes *C. tritaeniorhynchus* and *C. vishnui*, is more frequently found in rural and agricultural settings, where they breed in irrigation channels, paddy fields, and waterlogged farmland (Sudeep & Shil, 2023). In Aligarh, the seasonal monsoon rainfall is key to shaping where *Culex* mosquitoes are found. The rain creates temporary water bodies that serve as breeding sites, leading to a rise in mosquito density and their movement throughout the district. After the monsoon, we often see a peak in adult populations, largely due to better survival rates for larvae and the right humidity (Dhiman *et al*., 2022). Even in the dry season, *Culex* mosquitoes can continue to survive because of permanent water sources and drainage systems that aren't properly maintained. Urbanization, a growing population, poor sanitation, and certain farming practices are all playing a big role in changing where mosquitoes are found. When human homes, animal shelters, and water sources are so close together, it creates a perfect environment for mosquitoes to thrive. In the Aligarh district, the way *Culex* mosquitoes are spread out shows a clear link between environmental conditions and human activities. This highlights the importance of having targeted strategies for monitoring and controlling these mosquito populations based on specific locations.

Geographical and Environmental Profile of Aligarh District

Aligarh district is situated in the western region of Uttar Pradesh, India, lying between approximately 27°29′ to 28°11′ N latitude and 77°29′ to 78°38′ E longitude. This area is part of the fertile upper Gangetic plain and is surrounded by the districts of Bulandshahr, Hathras, Mathura, Kasganj, Etah, and Budaun. Spanning around 3,650 km², the district features a mostly flat

landscape with gentle slopes, which can cause water to collect in the lower areas, greatly affecting the local mosquito ecosystem (District Census Handbook, Aligarh, 2011). Aligarh has a subtropical monsoon climate, which means it goes through three main seasons: summer (from March to June), monsoon (July to September), and winter (October to February). Summers can get really hot, often pushing past 40 °C, while winters are much milder, with temperatures sometimes dipping below 5 °C. On average, the district sees about 650 to 750 mm of rainfall each year, most of which falls during the southwest monsoon. These weather conditions create a perfect environment for mosquitoes to breed and thrive, especially during and right after the monsoon season (Dhiman *et al*., 2022). The environmental scene in Aligarh is a fascinating blend of bustling urban areas, quaint rural villages, and vast stretches of farmland. The region thrives on major crops like wheat, rice, sugarcane, and pulses, all thanks to a network of canal irrigation and groundwater extraction. The practice of paddy cultivation, along with flood irrigation, leads to the formation of temporary and semi-permanent water bodies, which become perfect breeding grounds for mosquitoes, particularly the *Culex* species. Additionally, you'll find ponds, wetlands, irrigation channels, and waterlogged fields dotting the rural landscape (Singh & Prakash, 2021). The urban and peri-urban areas of Aligarh are dealing with significant environmental challenges, primarily caused by rapid population growth, unplanned expansion, and insufficient waste management systems. Open drains, blocked sewage channels, and improper disposal of household wastewater lead to ongoing water stagnation. These polluted aquatic environments are particularly inviting for *Culex* mosquitoes, which thrive in nutrient-rich and murky waters (Kumar *et al*., 2021). Additionally, raising livestock near human dwellings increases the availability of hosts for these blood-feeding mosquitoes, exacerbating the problem. The combination of Aligarh district's geographical location, climate, and environmental features makes it a prime spot for mosquito growth. Recognizing this geographical and environmental landscape is key to interpreting how mosquitoes are spread and to developing effective, targeted strategies for vector surveillance and control.



Habitat Diversity and Larval Breeding Sites

Habitat diversity is essential for the abundance, survival, and distribution of *Culex* mosquitoes. In the Aligarh district, a variety of natural and human-made aquatic environments provide ideal breeding grounds for *Culex* larvae, showcasing the ecological flexibility of this mosquito genus. Unlike their Anopheles counterparts, *Culex* species can thrive in polluted and nutrient-rich waters, allowing them to take advantage of various larval habitats found in urban, peri-urban, and rural areas. In Aligarh, one of the most crucial spots for larval breeding is found in polluted water bodies, such as open sewage drains, wastewater channels, and stagnant pools that take in domestic waste. These areas are rich in organic material and microbial life, offering plenty of food for *Culex* larvae, particularly *Culex* quinquefasciatus (Kumar *et al*., 2021). The poorly kept drainage systems and the water that collects near residential neighborhoods create ideal conditions for larval development to thrive throughout much of the year. Ponds that sit still, ditches, and wetlands are vital breeding habitats, especially in peri-urban and rural regions. These bodies of water often have decaying plant matter and algae, which really help larvae, thrive. In Aligarh's agricultural zones, irrigation channels, waterlogged fields, and rice paddies set the stage for the breeding of *Culex vishnui* group species, like *C. tritaeniorhynchus*, which are known to be associated with the spread of Japanese encephalitis (Sudeep & Shil, 2023). In urban and semi-urban settings, septic tanks soak pits, and household water storage structures serve as significant man-made habitats for larvae. Sadly, these areas are frequently neglected in vector control initiatives, enabling *Culex* populations to survive even in dry spells (Becker *et al*., 2020). Moreover, discarded items like containers and tires, along with construction sites, can lead to localized breeding, particularly during the rainy season. Environmental factors like water temperature, pH levels, nutrient load, and organic content play a significant role in determining larval density and survival rates. Additionally, human activities such as unplanned urban development, poor waste management, and agricultural irrigation practices are contributing to an increase in available habitats. The variety and longevity of larval breeding sites in the Aligarh district highlight the importance of implementing habitat-based monitoring and source reduction strategies as part of comprehensive vector management programs.

Feeding Behavior and Host Preference

Culex mosquitoes' feeding habits and host preferences are key ecological traits that significantly affect their ability to transmit diseases. In Aligarh district, these mosquitoes primarily feed at night, with their most active biting times occurring from dusk to dawn. This nocturnal behavior raises the likelihood of human contact, especially in areas where people sleep outdoors or in homes that lack proper protection during the warmer months. Their tendency to feed at night and indoors boosts their effectiveness as disease vectors (Service, 2012). *Culex* mosquitoes are quite adaptable when it comes to their feeding habits. They don’t hesitate to snack on humans, livestock, birds, and other vertebrates, depending on what’s available in their surroundings. In the rural and peri-urban areas of Aligarh, the close quarters of cattle sheds, poultry farms, and human homes lead to frequent changes in their feeding choices. This mixed feeding behavior plays a crucial role in the spread and maintenance of zoonotic pathogens, like the Japanese encephalitis virus, which relies on birds and pigs as reservoirs (Sudeep & Shil, 2023). *Culex* quinquefasciatus, the most common mosquito in urban settings, shows a notable preference for humans but also feeds quite a bit on cattle, particularly in regions with a lot of livestock. It’s pretty typical for these mosquitoes to take several blood meals in one reproductive cycle, which can heighten the risk of spreading diseases (Becker *et al*., 2020). The choice of host is affected by several things, including how many hosts are available, their body odor, the carbon dioxide they emit, and environmental factors like temperature and humidity. The way *Culex* mosquitoes feed is influenced by various social and environmental factors, including the type of housing, the use of bed nets, and the presence of artificial lighting. To effectively predict how diseases spread and to create targeted strategies for controlling these pests, it's crucial to understand their host preferences. Implementing measures like managing livestock, enhancing housing conditions, and using personal protective gear can greatly lower the risk of humans getting bitten by these infectious mosquitoes.

Role of Water Quality in Mosquito Proliferation

Water quality plays a crucial role in the ecosystem, particularly when it comes to mosquito breeding, larval survival, and overall population density. *Culex* mosquitoes, for instance, are closely linked to polluted and nutrient-rich water sources, making the quality of water a vital factor in their growth. In areas like Aligarh, where untreated domestic wastewater, agricultural runoff, and inadequate drainage systems are prevalent, the conditions often create a perfect environment for *Culex* species to thrive. The physicochemical parameters, including organic matter content, dissolved oxygen, pH, turbidity, and nutrient load, are vital for larval development. Studies reveal that *Culex* quinquefasciatus larvae do particularly well in water bodies that are rich in organic pollution and have low levels of dissolved oxygen, creating an environment that reduces natural predators and competitors (Kumar *et al*., 2022). Furthermore, increased nitrogen and phosphorus from sewage and agricultural runoff promote microbial growth, which serves as a primary food source for these mosquito larvae. Recent research indicates that polluted water bodies with moderate alkalinity and elevated biochemical oxygen demand (BOD) support significantly greater larval densities compared to cleaner or flowing water systems (Singh *et al*., 2023). The turbid water, rich in suspended solids, provides a refuge from predators and environmental stress, enhancing larval survival. In urban and peri-urban regions of Aligarh, stagnant drains and wastewater pools function as ongoing breeding sites, enabling mosquito populations to persist even during dry spells. Water temperature interacts closely with its quality, affecting how mosquitoes multiply. When the water gets warmer, it accelerates the metabolism of larvae and shortens their development time, which can lead to a swift rise in their numbers when nutrient conditions are

favorable (Dhiman *et al*., 2022). Furthermore, climate-related shifts in rainfall patterns can increase nutrient runoff into surface waters, indirectly enhancing mosquito productivity. Understanding how water quality impacts mosquito ecology is crucial for effective vector control. By improving wastewater management, cutting down on organic pollution, and ensuring proper water flow, we can significantly disrupt the habitats where larvae thrive. Therefore, it's important to weave water-quality interventions into vector management programs to help lower the number of *Culex* mosquitoes and the risks of disease transmission that come with them.

Public Health Importance of *Culex* Mosquitoes

Culex mosquitoes are a significant concern for public health because they spread various parasitic and viral diseases that impact millions globally. In India, especially in Uttar Pradesh, these mosquitoes play a major role in the prevalence of mosquito-borne illnesses, making them a key target for vector monitoring and control efforts. Their ability to thrive in different environments, preference for polluted water, and tendency to live near human populations only heighten their importance to public health. One of the key diseases spread by *Culex* mosquitoes is lymphatic filariasis, which is caused by the nematode *Wuchereria bancrofti*. In India, *Culex* quinquefasciatus plays a major role as the primary vector for this parasite, particularly in urban and peri-urban areas (WHO, 2023). Lymphatic filariasis is a long-lasting and debilitating condition that can lead to significant disability, social stigma, and economic hardship, especially for marginalized communities. Even with ongoing mass drug administration programs, the persistence of these vectors continues to pose a challenge to elimination efforts. *Culex* mosquitoes are significant carriers of various arboviral diseases, such as *Japanese encephalitis* (JE) and West Nile virus (WNV), along with other emerging flaviviruses. Within the *Culex vishnui* group, species like *C. tritaeniorhynchus* are particularly crucial for spreading JE, especially in rural areas where rice farming and livestock raising are prevalent (Sudeep & Shil, 2023). Recent research has pointed out the rising presence of WNV in certain regions of India, highlighting the increasing public health risks associated with *Culex* mosquitoes (Singh *et al*., 2022).

Integrated Vector Management Strategies

Integrated Vector Management (IVM) is a holistic and sustainable strategy that the World Health Organization recommends for managing mosquito populations and tackling the challenges posed by vector-borne diseases. IVM focuses on making the best use of available resources by combining environmental, biological, chemical, and community-driven methods, all tailored to local ecological and epidemiological insights. For *Culex* mosquitoes, which tend to flourish in dirty and stagnant water, IVM offers a solid framework for effective long-term control. Environmental management is at the heart of Integrated Vector Management (IVM). It involves reducing sources of disease by improving sanitation, ensuring proper waste disposal, maintaining drainage systems, and getting rid of stagnant water. Making changes to larval habitats like covering septic tanks, enhancing wastewater flow, and managing irrigation has proven to significantly cut down on *Culex* mosquito breeding (WHO, 2023). In urban and peri-urban areas, keeping drains clean and managing solid waste effectively can make a big difference. Biological control methods provide eco-friendly alternatives to chemical solutions. For instance, using fish that eat larvae, like Gambusia affinis and Poecilia reticulata, along with bacterial larvicides such as Bacillus thuringiensis israelensis (Bti), has proven to be very effective against *Culex* larvae while keeping non-target organisms safe (Becker *et al*., 2020; Kumar *et al*., 2022). These approaches work particularly well in ponds, wetlands, and water storage areas. Chemical control is an essential aspect of Integrated Vector Management (IVM) when mosquito populations exceed acceptable limits. To avoid developing resistance to insecticides, it's important to use larvicides and adulticides thoughtfully. Recent studies stress the significance of monitoring resistance and rotating insecticides to keep them working effectively (Sarkar *et al*., 2021). Community involvement and health education play a crucial role in the effectiveness of IVM programs. Raising public awareness about where mosquitoes breed, how to protect ourselves and ways to prevent diseases can significantly boost community engagement and ensure long-term success. When these integrated vector management strategies are applied in a well-coordinated and evidence-based way, they can greatly lower *Culex* mosquito populations and the health risks they pose.

Conclusion

In Aligarh district, the ecological assessment of *Culex* mosquitoes shows how environmental factors, human actions, and climate all come together to influence their spread and the effects on public health. The subtropical climate, combined with widespread agriculture, contaminated water bodies, and insufficient sanitation, provides ideal conditions for these mosquitoes to breed. They find suitable habitats in places like sewage drains, stagnant ponds, irrigation channels, and septic tanks. Their knack for thriving in nutrient-rich and polluted waters means they can stick around all year long. *Culex* mosquitoes are known for their nighttime feeding habits, often targeting humans, livestock, and birds. This behavior boosts their ability to spread diseases like lymphatic filariasis, Japanese encephalitis, and West Nile virus. When you add poor water quality and nutrient-rich environments into the mix, it only makes things worse for mosquito populations. To tackle this issue effectively, we need an Integrated Vector Management approach that includes environmental sanitation, biological and chemical controls, and active community involvement. Strengthening surveillance, improving waste and water management, and raising public awareness are all vital steps to reduce the risks of mosquito-borne diseases and enhance public health in the Aligarh district.

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