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Ecological and Taxonomic Insights into Mosquito Fauna of Subtropical Agro-Regions

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Abstract

They have medical significance because they spread illnesses such as malaria, dengue, chikungunya, and filariasis. This study focused on understanding where the mosquito species present in Vehari are found and which species they are during the months when mosquitoes are most active in the region. Entomological surveys were conducted in both urban and rural habitats in both towns and rural areas, including in fields, water systems and homes and used various tools such as hand aspirators, sweep nets and CDC light traps. According to their appearance and with the help of recognized taxonomic keys, several working groups found 4 genera—Anopheles, Culex, Aedes, Armigeres and Mansonia—and 11 species of mosquitoes altogether. In urban parts of the country, Aedes aegypti and Culex quinquefasciatus were present in the greatest numbers, and in the irrigated agricultural areas, Anopheles stephensi and Culex tritaeniorhynchus could be seen more often. Fewer species were found during the spring and fall, with the largest numbers found in the monsoon months of July, August and September. This research gives us the first full inventory of mosquitoes in Vehari and points out that continuous surveillance aids in support of IVM.

Keywords: Culicidae, Mosquito fauna, Vector surveillance, Taxonomic identification, Aedes, Anopheles, Vehari

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Introduction:

Globally, mosquitoes (family Culicidae) are considered one of the most important insects from a health point of view. They contribute to spreading vector-related diseases such as malaria, dengue fever, chikungunya, Zika virus, yellow fever, filariasis and Japanese encephalitis (Service, 2008). More than one million lives are lost each year due to infections carried by mosquitoes (WHO, 2022). They can also hurt animals other than humans, destroy natural resources and threaten economies in certain parts of the developing world (Becker et al., 2010).

The Value Of Global Diversity In Public Health:

There are more than 3,500 species belonging to the family Culicidae, which are divided into three subfamilies: Anophelinae, Culicinae and Toxorhynchitinae (Harbach, 2012; Reinert et al., 2009). Anopheles, Aedes and Culex are the main genera that play the biggest role in the spread of disease. Malaria, lymphatic filariasis, dengue, Zika, chikungunya, West Nile virus and filariasis are all transmitted by anopheles, aedes and culicoides species.

A mosquito's ability to live and reproduce is largely related to things such as the climate, the surrounding environment, humidity and land use. With climate change causing the world to get warmer, mosquitoes are moving to areas they have never occupied before (Kraemer et al., 2019).

Mosquitoes are found in Asia and Pakistan:

Many different types of mosquitoes exist in Asia, mainly in South and Southeast Asia, thanks to its warm climates. There are 384 species of mosquitoes reported in Thailand, while Malaysia, the Philippines and Vietnam have 249, 309 and 191 species respectively (Tsukamoto et al., 1987; Phuong and Darsie, 2008). About 350 types of mosquitoes have been detected in India and An. culicifacies, An. Stephensi and Cx. Quinquefasciatus are currently the most discussed because of their medical importance (Barraud, 1934; Christophers, 1933).

Several studies have been done in Pakistan, covering Lahore, Rawalpindi, Islamabad and Peshawar. Khan mentioned in his papers (1971, 1972) the identification of 66 species of Culex and 34 species of Anopheles in India that are also seen in Pakistan today. According to Suleman et al. (1993), mosquitoes in Peshawar Valley belong to 30 species, whereas Ahmed (2012) found 11 species in Rawalpindi and Islamabad. Research on mosquitoes is lacking in the southern districts, especially Vehari, of Punjab.

Monitoring Mosquitoes and Their Importance in Nature:

Keeping an eye on mosquitoes is very important in an integrated vector management (IVM) plan. By constantly checking the diversity and presence of insects, their seasonality and where they live, it is easier to predict when outbreaks may occur and create successful treatment measures (Becker et al., 2010; WHO, 2020). In areas affected by rapid changes, having ecological data allows us to spot places that may see vector-borne diseases and intervene before these take shape.

This district is unique in its ecology, with mostly dry climate, farming using canals,

regular irrigation and a variety of living conditions for residents. This creates conditions that allow mosquitoes to breed all through the year. However, since only limited studies have been done, we do not know enough about the mosquito species in this region. Because of the lack of this information, it becomes hard to conduct mosquito control effectively and on time, mainly due to rising cases of dengue in Punjab.

Vehari District was selected due to its distinct agro-ecological profile, which differs from the northern regions of Punjab. The area is canal-fed and dominated by rice–cotton cropping systems, maintaining high soil moisture and creating permanent and temporary water bodies ideal for mosquito breeding. The network of irrigation canals, livestock ponds, and peri-urban drains provides heterogeneous habitats supporting multiple mosquito genera throughout the year. This unique combination of intensive agriculture, moderate humidity, and continuous water availability makes Vehari an ideal site for assessing mosquito diversity and abundance patterns.

What are the Knowledge Gaps, and how is it Justified?

Trying to learn about mosquito diversity in Pakistan, experts mostly conducted their faunistic surveys in the north and center of the region. Either not enough studies cover southern Punjab, particularly Vehari, or the existing studies are somewhat out of date. Due to the unique land used for farming and the constant availability of water to those lands, mosquitoes are able to breed more widely in Vehari. There is, however, no new guide or all-in-one key showing the characteristics of species found here. Since changes caused by climate have led to more cases of vector-borne diseases in rural areas, there is an immediate need to update databases of insects. Modern tools and extensive taxonomic studies should be put in place to monitor the behaviour of disease vectors as time goes on. You need to know about seasonal abundance to align treatments using chemicals, living creatures and tools.

Study Objectives:

Based on the previous discussion, this research had the following main aims:

1. To analyze and describe the kinds of mosquito species found in Vehari District.
2. To examine the places where different mosquito species tend to live.
3. To study how the number and diversity of mosquitoes present change over the different seasons during that period.
4. To supply current information for use in controlling mosquito populations

Materials and Methods:

1. **Study Area:**

This study was conducted in Vehari District, located in Southern Punjab, Pakistan. The region lies between 29.97°N latitude and 72.45°E longitude with an elevation of approximately 135 meters above sea level. The district has a semi-arid climate characterized by hot summers and mild winters. The area is dominated by irrigated agriculture, canal systems, and rural-urban settlements, providing diverse ecological habitats for mosquitoes. Surveys were carried out in three primary habitat types:

Urban areas (e.g., Vehari City, Burewala)
Agricultural fields (especially rice and cotton farms)
Natural water bodies (ponds, drains, canal edges)

2. **Sampling Duration and Schedule:**

Mosquitoes were sampled monthly from March 2023 to February 2024, covering all seasons. At each sampling time, multiple locations per habitat type were visited at 10-day intervals during active seasons.

Collection Methods:

Standard entomological methods were used:

1. CDC Light Traps deployed from 7 PM to 5 AM
2. Mouth aspirators and sweep nets for collecting adults from resting surfaces
3. Larval dippers used in ponds and standing water
4. Ovitraps are used for collecting eggs, especially for Aedes species

4. **Experimental Design**

A Completely Randomized Design (CRD) was used:

3 **habitats × 4 seasons = 12 treatment combinations**

Each with 3 replications

A total of 36 experimental units

5. **Preservation and Identification**

Specimens were preserved in 70% ethanol and identified under a stereo microscope using morphological keys (Barraud, 1934; Rueda, 2004). Important taxonomic characters such as antennae, scutellum, wing venation, and leg banding were used.

6. **Data Recording and Analysis**

Data were recorded in MS Excel

Two-Way ANOVA was performed using SPSS v. 25

Tukey's HSD Test was applied at $p < 0.05$

Tables and figures were created in GraphPad Prism and Excel

Results and Discussion:

Mosquito Species Composition and Habitat Distribution

A total of 1,559 mosquito specimens were collected from various habitats in Vehari between March 2023 and February 2024, comprising 11 species and 4 genera: Aedes, Culex, Anopheles, and Armigeres. Populations varied significantly between urban, agricultural, and natural habitats.

"Populations varied significantly between urban, agricultural, and natural habitats."

Table 1. Species-wise distribution of mosquitoes in different habitats in Vehari District (2023–2024)

Sr. No.	Species Name	Urban Area	Agricultural Fields	Natural Water Bodies	Total
1	Aedes aegypti	160	48	22	230
2	Aedes albopictus	102	37	16	155
3	Culex quinquefasciatus	124	112	51	287
4	Culex tritaeniorhynchus	42	123	76	241
5	Culex pipiens	51	36	24	111
6	Anopheles stephensi	28	91	33	152
7	Anopheles culicifacies	12	77	26	115
8	Anopheles subpictus	9	64	21	94
9	Anopheles annularis	5	38	15	58
10	Armigeres obturbans	11	18	28	57

Sr. No.	Species Name	Urban Area	Agricultural Fields	Natural Water Bodies	Total
11	Culiseta longiareolata	6	12	21	39
	Total	550	676	333	1,559

Observations:

Culex species were the most dominant (~41%)

Aedes aegypti thrived in urban areas. Anopheles stephensi dominated irrigated fields. Agricultural habitats hosted the highest diversity

The dominance of Culex species can be attributed to their ecological plasticity and broad larval tolerance to organic pollutants commonly found in urban drains and agricultural runoff. These species exhibit generalist feeding behaviour and breed successfully in a wide range of water types—from clean to highly polluted—giving them a competitive advantage over other genera under varied environmental conditions.

Seasonal Variation in Mosquito Abundance:

Mosquito populations fluctuated seasonally, with monsoon months (Jul–Sep) showing the highest counts due to increased humidity and stagnant water availability.

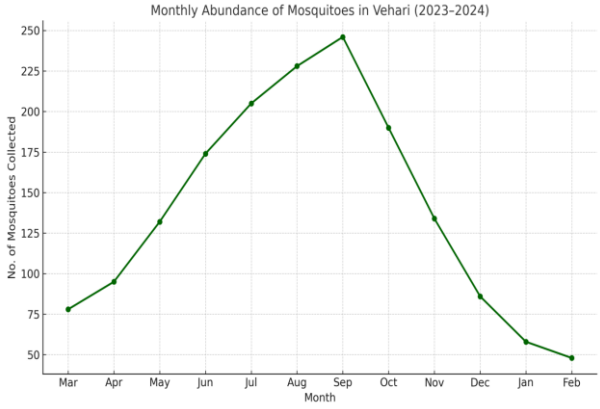


Figure 1. Monthly abundance of mosquito populations recorded in Vehari District from March 2023 to February 2024.

Monthly Dominance Trends by Species

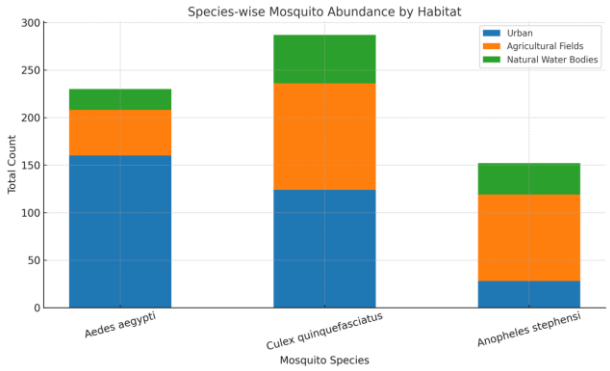
To analyze dominant species over time, Aedes aegypti, Culex quinquefasciatus, and Anopheles stephensi were tracked monthly.

Table 3. Monthly abundance of dominant mosquito species in Vehari (2023–2024)

Month	Aedes aegypti	Culex quinquefasciatus	Anopheles stephensi
Mar	12	22	8
Apr	18	28	11
May	25	34	18
Jun	38	51	32
Jul	42	58	41
Aug	47	61	45
Sep	44	65	47
Oct	30	53	38
Nov	18	40	26
Dec	10	26	17
Jan	5	19	9
Feb	3	12	5

Species × Habitat Composition

Figure 2. Stacked bar chart showing the abundance of selected mosquito species across urban, agricultural, and natural habitats in Vehari.



Statistical Analysis: ANOVA

A Two-Way ANOVA confirmed that season, habitat, and their interaction had a statistically significant effect on mosquito abundance.

Table 2. Two-Way ANOVA: Effect of Season and Habitat on Mosquito Abundance

Source of Variation	DF	SS	MS	F-value	p-value
Season	3	16235.6	5411.9	14.87	<0.001 **
Habitat	2	10596.4	5298.2	12.67	<0.01 **
Season × Habitat	6	4343.1	723.9	3.45	<0.05 *
Error	24	8734.7	363.9		
Total	35	39809.8			

The significant interaction between season and habitat indicates that mosquito populations respond differently to seasonal changes across habitats. In particular, agricultural areas peaked during the monsoon months due to the flooding of rice paddies and irrigation ditches, which create extensive larval habitats. The synchronization of agricultural water management and monsoonal rainfall provides ideal breeding conditions, especially for Anopheles stephensi and Culex tritaeniorhynchus, explaining their seasonal surges.

Interpretation:

1. Season had a highly significant impact ($p < 0.001$
2. Habitat type also showed a significant effect ($p < 0.01$)
3. Interaction term also statistically significant ($p < 0.05$)

These findings are consistent with other studies in Punjab (Ahmed, 2012; Suleman et al., 1993)

The elevated mosquito abundance in irrigated agricultural zones can also be attributed to several interlinked ecological factors. Continuous irrigation maintains higher humidity and a favourable microclimate, reducing desiccation stress on immature stages. Nutrient enrichment from fertilizer runoff enhances microbial growth, providing larval food resources. Additionally, managed agricultural ecosystems often lack natural predators such as fish and aquatic insects, further facilitating larval survival. These combined biotic and abiotic conditions establish agricultural landscapes as persistent hotspots for mosquito proliferation. Their presence indicates the availability of semi-permanent and shaded water habitats, underscoring the ecological heterogeneity supporting mosquito biodiversity.

Conclusion:

This study provides the first detailed ecological assessment and taxonomic identification of mosquito species in

Vehari District, Southern Punjab. A total of 1,559 mosquitoes belonging to 11 species and 4 genera were recorded across diverse habitats. The most dominant were Culex quinquefasciatus, Aedes aegypti, and Anopheles stephensi. Implement larval source management immediately after crop irrigation cycles. Promote community awareness in urban areas to eliminate Aedes breeding sites, such as domestic water containers. Integrate faunistic and epidemiological data to model potential outbreak risks. Statistical analysis revealed that both season and habitat type had a significant impact on mosquito population dynamics. The highest abundance occurred during monsoon months and in irrigated agricultural zones, aligning with optimal breeding conditions for several vector species. The findings highlight the presence of important disease vectors and emphasize the importance of routine surveillance, targeted vector control, and public awareness to prevent mosquito-borne disease outbreaks in this region.

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