Research Article

Species Distribution, Abundance and Diversity of Mosquitoes (Diptera: Culicidae) in District Jhelum (Punjab, Pakistan)

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Abstract | Mosquitoes the deadliest animals on the earth, transmit lethal diseases in humans as well as animals. Spatial distribution of mosquitoes provides clues for their precise and accurate control. In this study, which was conducted in 2014-16, different habitats including, graveyards, scrapyards, forest areas, streams, crops, residential areas, and animal sheds were specified in Jhelum district. Surveys for the collection of mosquitoes were made and a total of 365 specimens were collected. These specimens were identified as *Culex* (9), *Anopheles* (6), *Lutzia* (2), *Aedes* (2), and *Armigeres* (2) and deposited in the Biosystematics Laboratory of Pir Mehr Ali Shah, Arid Agriculture University Rawalpindi. Quantitative habitat webs and diversity indices show that scrapyard, animal sheds, and residential areas were the most abundant habitats respectively, while areas near stream were found to be the least abundant habitats. These microhabitats, which are the most abundant ones act as hotspots in case of mosquito-borne epidemic, which should be targeted to control epidemic.

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Introduction

Mosquitoes (Diptera: Culicidae) are an important part of aquatic and aerial ecosystem, maintaining the balance of an aquatic ecosystem, they serve as food and predator in aquatic systems. Immature stages of mosquitoes become the food of fishes and odonata as, these are packages of protein and nutrients and as a predator, they feed on different microorganisms. Adult mosquitoes live in different types of habitats depending on the suitability for different species (Roberts *et al.*, 1996). Mosquitoes show a preference for some particular host (Burkett-Cadena *et al.*, 2011).

Different environmental factors affect the spatial distribution of mosquitoes. These factors include the availability of blood hosts (Kuntz *et al.*, 1982),

vegetation (Service, 1981), the resting place (Harwood and Halfhill, 1960; McCrae *et al.*, 1976), artificial resting places (Gillies, 1955; Chandler *et al.*, 1975) and the oviposition sites (Meek and Olson, 1976).

Feeding behavior provides information regarding the hosts like birds, animals, and humans so the habitat. Different species of mosquitoes prefer different types of habitat (D'Antonio and Spielman, 2002). Each habitat has its own specific physical characteristics, e.g. graveyards have less vegetation, thus low humidity and raised temperature. Parks and forest areas have high humidity and low temperature due to surplus vegetation. Animal sheds have high humidity and high temperature due to respiration of animals. Surroundings of streams (Suleman *et al.*, 1993) are cool as transpiration of water vapors is high. Humidity and temperature remain changing in houses due to the activities of humans (Mehmood *et al.*, 2021). Precipitation directly affects the population of mosquitoes and the oviposition as precipitation creates the habitat for egg laying as well as habitat for their larvae to grow (Aniedu, 1992; Vandyk and Rowley, 1995; Dhileepan, 1996; Lindblade *et al.*, 1999; Webb and Russell, 1999).

Habitat distribution of mosquitoes provides a map of the mosquitoes in relation to their habitats, thus in case of any epidemic spread in an area, this map gives the information of hotspot of any mosquitoes in that region, making the control practices much easier.

Materials and Methods

The study was conducted during 2014-16 in Jhelum District of Pothwar region, Punjab, Pakistan. Microhabitats, including animal shed, houses, graveyards, parks, streams, crops, and forest areas were specified for qualitative and quantitative analysis.

With the help of aerial net and different traps, including dry ice trap and light trap mosquitoes were captured: these were killed in killing bottle containing potassium cyanide in it and preserved in wooden boxes for identification (Mehmood *et al.*, 2016), which was done under the CZM6 microscope using available literature and inventories including Barraud (1934), Tyagi *et al.* (2015), Qasim *et al.* (2014).

The mosquitoes collected from different habitats were placed separately for proper sorting quantitively and qualitatively.

The quantitative data was used to construct quantitative habitat webs, while PAST software 4.0 was used to determine diversity indices.

Results and Discussion

The web (Figure 1) shows diversity of 21 mosquito species belonging to *Culex* (9), *Anopheles* (6), *Lutzia* (2), *Aedes* (2) and *Armigeres* (2), comprising of 365 specimens indifferent habitats. *Anopheles maculatus* was collected from two habitats, including animal sheds and streams. High abundance was found in animal sheds, while low abundance was found in streams. *A. annularis* was collected from three habitats, including animal sheds, residential areas, and streams. High abundances were founded from animal sheds and residential areas, while the low abundance was found from streams.

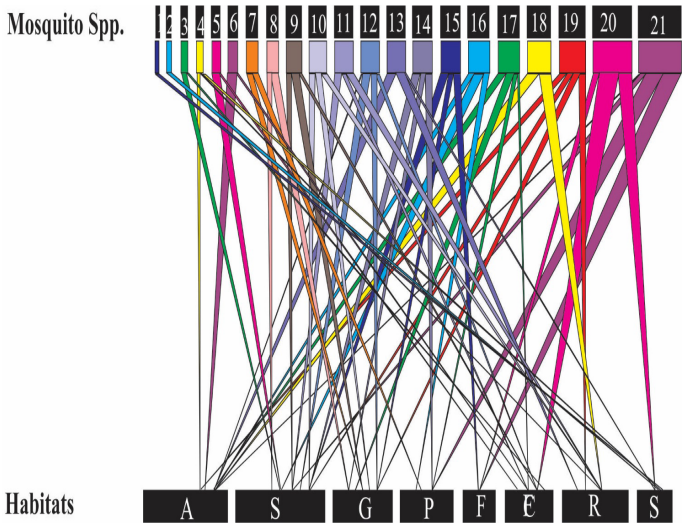

Figure 1: *Quantitative habitat web of mosquitoes found in Jhelum district during 2014-16*
A: Animal sheds; S, Scrap yard; G, Graveyard; P, Park; F, Forest area; C, Crop area; R, Residential Area; S, Stream.
1: Ae. aegypti; 2: Ae. albopictus; 3: An. maculatus; 4: An. tesselatus; 5: An. theobaldi; 6: Cx. seniori; 7: Cx. pluvialis; 8: Cx. tenuipalpis; 9: An. stephensi; 10: An. annularis; 11: An. culicifacies; 12: Cx. vishnui; 13: Cx. malayi; 14: Lu. vorax; 15: Lu. raptor; 16: Cx. cornutus; 17: Ar. kuchingensis; 18: Cx. vagans; 19: Cx. edwardsi; 20: Cx. fuscitarsis; 21: Ar. obturbans.

Culex vagans was collected from four habitats, including animal sheds, graveyard, parks and crop area. High abundances were found in animal sheds graveyard yard, while the lowest abundance was found in crop areas. *C. edwardsi* was collected from four habitats, including animal sheds, scrapyards, graveyards, and crop areas. The highest abundance

was found in scrapyards, while the lowest abundance was found in animal sheds. *C. vishnui* was collected from three habitats, including scrap yard, graveyard, and crop area. The highest abundance found was from graveyard, while the lowest abundance was found in crop areas. *C. malayi* was collected from three habitats, including animal sheds, scrapyards, and parks. The high abundance was found from scrapyards, while low abundance was found from both animal sheds and parks.

C. fuscitarsis was collected from four habitats, including animal sheds, scrapyards, graveyards, and residential areas. High abundance was found in animal sheds, graveyards, and residential areas, while low abundance was found in scrapyards.

Culex cornotus was collected from three habitats, including scrap yard, graveyard, and park. The highest abundance was found in scrapyard, while the lowest abundance was found in graveyard. *Culex seniori* was collected from two habitats, including graveyards and parks. The abundances found in these habitats were the same. *Culex pluvialis* was collected from two habitats, including scrap yard and crop area. High abundance was present in scrapyard, while low abundance was found in crop areas. *Culex tenuipalpis* was collected from two habitats, including scrap yard and crop area. High abundance was found in scrapyards, while low abundance was found in crop areas.

Lutzia raptor was collected from three habitats, including scrap yard, crop area, and residential area. The highest abundance was found in residential areas, while the lowest abundance was found in crop areas. *L. vorax* was collected from three habitats, including scrapyard, graveyard, and residential area. The abundances found in these habitats were all the same.

Aedes aegypti was recorded from six habitats, including stream, park, forest area, residential area, graveyard and scrap yard the abundance was found low in graveyard and scrap yard, where the humidity was low, vegetation was less and the human movement and activities were less.

A. albopictus was present in the highest abundance in parks, while the lowest was presescrapyardsapyard. Our results are in accordance with Rajput and Singh (1990), Bareera *et al.* (2011), Ilahi and Salman (2013), and Poveda *et al.* (1999). *A. albopictus* was recorded from the graveyard, forest area, residential area, park, stream, and scrap yard. Our results are in accordance with Fakoorziba and Vijayan (2008).

A. stephensi was collected from three habitats, including animal sheds, residential areas and streams. High abundance was found in animal sheds and residential areas, while low abundance was found in streams. The results coincides with the findings of Ali *et al.* (2013, 2015).

A. culicifacies and *A. tesselatus* shared the same habitats, including animal sheds, residentiareasrea, and streams. High abundances of *A. culicifacies* were found from animal sheds and streams, while low abundance was found from residential areas. *A. tesselatus* specimens were found in equal abundances from these habitats. Our findings regarding *A. culicifacies* are in partial accordance with Ali *et al.* (2013), Pal and Dutta (1992), and Fakoorziba and Vijayan (2008) as in addition to other habitats we also collected *A. culicifacies* from animal shed, which depicts the zoophilic nature of his mosquito. We collected *A. splendidus* from houses and animal sheds, while Ilahi and Salman (2013) had collected from rice fields.

A. theobaldi was collected from two habitats, including animal sheds and residential areas. The abundances found from these habitats were the same.

Armigeres obturbans was collected from four habitats, including animal sheds, scrapyard, park, and forest area. The highest abundance was found in forest area, while the lowest was found in animal sheds. *A. kuchingensis* was present in forest areas, parks, and standing water in almost the same abundance.

A. kuchingensis was recorded from different habitats, including parks, forest areas, residential areas, and streams, our results are in conformity with Tyagi *et al.* (2015).

A. obturbans was recorded from seven different habitats, including Park, forest area, stream, animal shed, scrap yard, and crop area. Our results are in accordance with Rajput and Kulkarni (1990), Rajput and Singh (1990), Ilahi and Salman (2013). Our results are in partial accordance with Ali *et al.* (2015) as we have not found any *A. obturbans* from houses. This may be due to the preference of high vegetation and humidity in the residential areas of this region.

Table 1: *Diversity indices of mosquitoes in different habitats of district Jhelum.*

Diversity indices	Habitats							
	Animal shed	Scrap yard	Graveyard	Park	Forest area	Crop area	Residential area	Stream
Simpson index	0.87	0.89	0.85	0.72	0.36	0.66	0.84	0.73
Shannon index	2.20	2.27	1.93	1.45	0.55	1.49	1.93	1.60
Evenness	0.82	0.97	0.98	0.85	0.86	0.63	0.86	0.71

Maximum Simpson index (0.89) was recorded in scrapyard, while the least (0.36) in forest area, followed by crop area (0.66), park (0.72), stream (0.73), residential area (0.84), graveyard (0.85), and animal shed (0.87), respectively. Shanon index was recorded maximum (2.27) in scrapyard, while the least (0.55) in forest area, park (1.45), crop area (1.49), stream (1.60), graveyard (1.93), residential area (1.93), and animal shed (2.20), respectively. Evenness was recorded maximum (0.98) in graveyard, while the least (0.63) in crop area, followed by stream (0.71), animal shed (0.82), park (0.85), forest area (0.86), residential area (0.86) and scrap yard (0.97), respectively (Table 1).

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Novelty Statement

From this specific area mosquitoes were not explored before. The Habitat Web Structure has been introduced for the first time to demonstrate hotspots.

Author's Contribution

Arif Mehmood: Conceived the idea, conducted the research, analysis of data and overall management of article.
Muhammad Naeem: Coneived the idea, analysis of data and technical input at every step.
Abu Bakar Muhammad Raza: Technical inputs, data analysis.
Muhammad Asam Riaz: Technical inputs and conclusion.
Muhammad Zeeshan Majeed: Technical inputs and, results and discussion.
Nadra Khan: Overall management of article and references.
Waqas Raza: Overall management of article and methodology.

Conflict of interest

The authors have declared no conflict of interest.

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