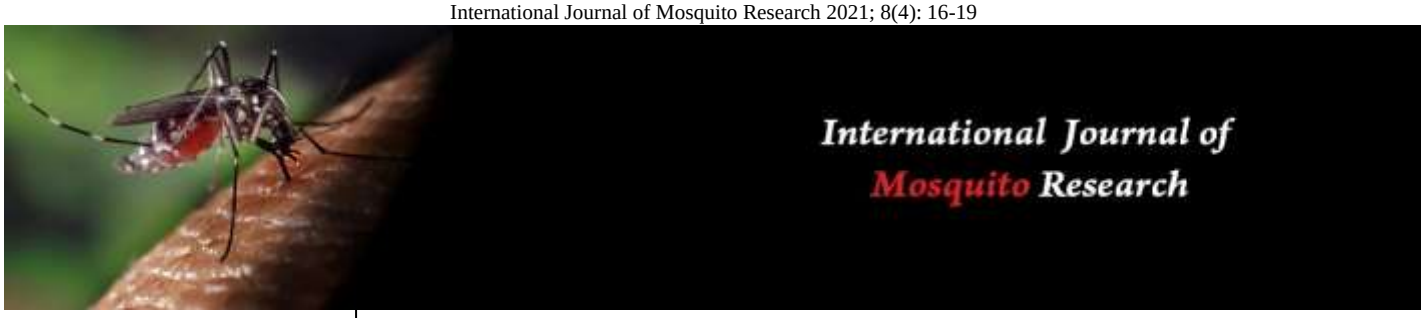

ISSN: **2348-5906**
CODEN: **IJMRK2**
IJMR 2021; 8(4): 16-19

www.dipterajournal.com
Received: 09-05-2021
Accepted: 12-06-2021

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Study on mosquito (Diptera: Culicidae) diversity in Jodhpur district of the Rajasthan state

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Abstract
The present study was conducted to determine the diversity of mosquito species in the Jodhpur district of Rajasthan state. The study was undertaken in a monsoon session for a period of 12 days (September 18, 2020 to September 29, 2020). Larvae, eggs, and adult stages of mosquitoes were collected to generate information about the diversity of mosquito fauna in the district. Total 651 specimens, represented 4 genera and 13 species was recorded in the study namely, *Culex*, *Aedes*, *Anopheles* and *Armigeres*. *Culex* (n=297) was found as dominant genus followed by *Aedes* (n=256), *Anopheles* (n=77) and *Armigeres* (n=21).

Keywords: Mosquito diversity, Jodhpur, *Culex*, *Aedes*, *Anopheles*, *Armigeres*

1. Introduction
Mosquitoes are the vectors of arboviruses, protozoans, and nematodes and over 500 million cases of vector-borne diseases including dengue, malaria, filaria, Japanese encephalitis, West Nile virus and Zika viruses annually globally [1, 4]. The management of vector-borne disease transmission is mainly dependent on mosquito control programmes. The information of mosquito species prevalence and distribution is one of the determining factors for the assessment of vector-borne pathogen transmission risk in areas. Globally, around 3583 species of mosquitoes are reported. In India, 406 species belonging to 50 genera of mosquitoes are listed [5].
The study area Jodhpur comprises plain sandy terrain with scanty or less vegetation. It lies between 26.2389° north latitudes to 73.0243° east longitudes and 250-300 meter above the sea level. The climate of the district is extremely hot and arid. The annual average rainfall is 366 mm but this is not uniform throughout the year. The district receives most of the rainfall from august to mid-September which favour the development of breeding habitats for various mosquito fauna.
Vector borne diseases are one of the major emerging health problems in Rajasthan. Understanding the diversity and faunal richness is essential to develop an effective and efficient mosquito control program by the local authorities. The diversity among the mosquito species gives a knowledge on the density of vector species during the peak seasons and this understanding helps the authorities to develop better prevention and control strategies to prevent the outbreak of diseases in the area [6].
The present study provides the information about the diversity and distribution of vector species in Jodhpur district.

2. Materials and methods
2.1 Study area
The present study was carried out at Jodhpur, the arid zone of Rajasthan state. Spanning an area of about 22850 km^2 located on the western side of that state. The climate of Jodhpur is hot and semi-arid during the dry season but also contains a brief rainy season. The average rainfall is around 362 mm per year

2.2 Study period
The study was carried out from September 18, 2020 to September 29, 2020.

2.3 Mosquito collection
Various sampling methods were used to collect the different stages of mosquitoes during the survey. The sampling habitats of *Aedes* species' larvae include cement tanks, plastic containers, discarded tyres and tree holes whereas *Culex* species' larvae were reported from stagnant sewage water, ditches, puddles and polluted water pots. Besides, *Anopheles* species' larvae were collected from swamps, drainage ditches, rice fields and riverbeds containing algae. *Culex* and *Anopheles* larvae were collected by dipping methods with ladle containing 350 ml capacity whereas *Aedes* larvae were collected by glass pipette. The adult mosquitoes were collected with the help of a suction tube and BG-Sentinel trap. Eggs of *Culex* and *Anopheles* were collected from a breeding habitat with the help of a paintbrush while for *Aedes*, ovitrap filled with water and supplemented with yellow filter paper were settled.

2.4 Conservation of Specimens
Larvae were kept in a plastic container containing density 100larvae/L and fed with Brewer's yeast (35mg/L). Pupae were transferred into a separate water container and covered with a net. Adult mosquitoes were pinned and store in a foam box. Eggs with yellow filter paper were stored in a closed plastic bag without containing water.

2.5 Identification
All the collected stages were brought to the Diptera section, Zoological Survey of India, Kolkata (WB). The larvae and pupae were kept in the laboratory for adult emergence. The adult mosquitoes were identified to the species level using taxonomic keys described by Sirivanakarn (1976) [7], Barruad (1934) [8], Rattanarithikul (2005) [9] and Das *et al*. (1990) [10].

3. Results and Discussion
The present study recorded diversity of 13 species of mosquitoes belonging to 4 genera namely *Aedes, Culex, Anopheles* and *Armigeres. Aedes* species include *Aedes aegypti, Aedes albopictus* and *Aedes vittatus* which belonging to 2 genera namely: *Stegomyia* and *Fredwardsius.* The genus *Culex* was represented by 7 species belonging to single subgenera *Culex* whereas genus *Anopheles* includes 2 species, *Anopheles subpictus* and *Anopheles stephensi*, belonging to subgenera *cellia*. *Armigeres subalbatus* was the only species recorded from subgenera *Armigeres* (Table 1).

A total of 651 mosquitoes specimens were collected (Table 2) in which *Cx. quinquefasciatus* was the most abundant species (33.79%) followed by *Ae. Aegypti* (18.43%), *Ae. albopictus* (12.44), *Ae. vittatus* (8.44%), *An.* subpictus (6.14%), *An. stephensi* (5.68%), *Cx. gelidus* (3.99%), *Ar.* Subalbatus (3.22), *Cx. vishnui* (2.76%), *Cx. edwardsi* (2.61%), *Cx. whitei* (1.38%), *Cx. vagans* (0.30%) and *Cx. pseudovishnui* (0.76%).

Culex species comprised of 39.32% of the total mosquito fauna for the study period. Of these *Cx. quinquefasciatus* (n=220) was the most abundant species. The larval habitat of *Culex* species includes various polluted water bodies (Fig 1, 2).

Aedes species represented 45.62% of total mosquito fauna. Among these, *Aedes aegypti* (n=120) was recorded as the most prevalent species. These species were collected from various plastic containers, cement tanks, tyres and tree holes (Fig 3).

Anopheles formed 11.82% of total collection. The most abundant species was observed as *An. subpictus* (n=40). The larval habitat of the anopheline mosquito includes swamps, drainage ditches, rice field and riverbeds (Fig 4).

Armigeres subalbatus was the only species from *Armigeres* genus collected for the study period. However, only adult specimens were collected for the species. No larval habitats were reported.

The species collected during the survey all have potential clinical significance. Significant vectors for sicknesses like Dengue, chikungunya, yellow fever, Japanese encephalitis and filariasis were distinguished from the examination site. *Aedes aegypti* and *Ae. albopictus* are the potential vector for dengue [11, 12] and chikungunya [13] whereas *Cx. quiquefasciatus* and *Cx. gelidus* found responsible for Japanese encephalitis [14] and Bancroftian filariasis [15]. Prevalence of *Anopheles subpictus* and *An. stephensi* during the study period also supports the indigenous transmission of malaria in the area where they can acquire parasite from the migrant works that come from the malaria endemic areas of the country [16]. The study reported cohabitation of *Ae. aegypti* and *Ae. vittatus* in urban environments whereas rural and forest areas favour the breeding of *Ae. albopictus* and resulted in the exclusion of *Ae. aegypti* which also supports the previous studies [17].

Table 1: Diversity of mosquito species recorded in study area.

S. No.	Species	Habitat positive for larval breeding								
		CT	TY	TH	RB	RF	SW	PD	WL	OAC
1.	*Aedes (Stegomyia) aegypti*	+	+	-	-	-	-	-	-	*
2.	*Aedes albopictus*	+	-	+	-	-	-	-	-	*
3.	*Aedes (Fredwardsius) vittatus*	+	-	-	-	-	-	-	-	*
4.	*Culex (Culex) quinquefasciatus*	-	-	-	+	-	+	+	-	*
5.	*Culex (Culex) gelidus*	-	-	-	+	+	-	+	+	*
6.	*Culex (Culex) vishnui*	-	-	-	+	+	-	-	-	*
7.	*Culex (Culex) pseudovishnui*	-	-	-	+	+	-	+	-	*
8.	*Culex (Culex) vagans*	-	-	-	+	+	-	-	-	*
9.	*Culex (Culex) edwardsi*	-	-	-	+	-	-	+	-	*
10.	*Culex (Culex) whitei*	-	-	-	+	+	-	-	-	*
11.	*Anopheles (Cellia) subpictus*	-	-	-	+	+	-	+	-	*
12.	*Anopheles (Cellia) stephensi*	-	-	-	-	+	-	-	-	*
13.	*Armigeres (Armigeres) subalbatus*	-	-	-	-	-	-	-	-	+

+ = Present, - = Absent, * = Both larvae and adult

Abbreviation: CT – Cement tank, TY – Tyre, TH – Tree hole, RB- River bed, RF – Rice field, SW – Sewage water, PD – Puddle, WL, Well, OAC- Only adult catch.

Table 2: List of collected specimens.

Species	No. of Specimens
Aedes (Stegomyia) aegypti	120
Aedes albopictus	81
Aedes (Fredwardsius) vittatus	55
Culex (Culex) quinquefasciatus	220
Culex (Culex) gelidus	26
Culex (Culex) vishnui	18
Culex (Culex) pseudovishnui	5
Culex (Culex) vagans	2
Culex (Culex) edwardsi	17
Culex (Culex) whitei	9
Anopheles (Cellia) subpictus	40
Anopheles (Cellia) stephensi	37
Armigeres (Armigeres) subalbatus	21
Total	651

Fig 1: Larval habitat. *Cx. whitei* & *Cx. Edwardsi*

Fig 2: Larval habitat. A – *Cx. quiquefasciatus*, B – *Cx. pseudovishnui*, *Cx. gelidus* & *Cx. Vagans*

Fig 3: Larval habitat. A & B – Ae. aegypti, C – Ae. albopictus D – Ae. aegypti + Ae. vittatus

Fig 4: Larval habitat. *Anopheles subpictus* & *Anopheles stephensi*

4. Conclusion

The current study provides information about the diversity of Culicidae in the Jodhpur district of Rajasthan state. Total 651 specimens, belonging to 13 species and 4 genera have been recorded in the present study. The presence of various vector species of dengue, chikungunya, malaria, Japanese encephalitis and filariasis in the district suggests that vector surveillance strategies should be performed to prevent vector-borne diseases in the district. The current study was carried out for a short period and in selected areas therefore recommend further studies to be carried out to uncover a detailed checklist of mosquito composition.

5. Acknowledgment

The authors thank Dr. D. S. Suman (Scientist – D, ZSI, HQ) for funding and granted permission to conduct the survey. Authors also thank staff members of Zoological Survey of India, Jodhpur, Kapil Kumar (Ph.D. student, JNVU, Jodhpur) and students of the University of Kota to their great support and guidance.

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