International Journal of Mosquito Research

ISSN: **2348-5906**
CODEN: **IJMRK2**
IJMR 2022; 9(5): 57-60
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www.dipterajournal.com
Received: 25-06-2022
Accepted: 29-07-2022

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Species composition and habitat characterization of mosquito fauna in Kota and Barmer region of Rajasthan

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DOI: https://doi.org/10.22271/23487941.2022.v9.i5a.633

Abstract
The present investigation conducted to determine the diversity of mosquito fauna in two ecologically different regions of Rajasthan i.e., Kota and Barmer. Kota is in the south-eastern region of Rajasthan while Barmer is situated in the western part of Rajasthan. The study was carried out over a period of one year. The adult mosquito was collected by using aspirator, BG -Sentinal trap and the larval stages were collected using ladle and dipping method. Total 1258 species were reported in the Barmer region while 1450 species were reported from the Kota region. The most prevalent species in the Kota and Barmer regions was *Culex quinquefasciatus*.

Keywords: Mosquito diversity, kota, barmer, *culex quinquefasciatus*

Introduction
Mosquitoes (Diptera: Culicidae) are the tiny creatures responsible for various devasting diseases such as dengue, chikungunya, yellow fever, filariasis, encephalitis etc [1]. Currently, India is becoming one of the hotspots of mosquito-vectored diseases especially dengue. According to National Vector Borne Diseases Control Program, dengue alone contributes over 8.5 lakh cases and thousands of mortalities in the last five years from India (2015-2020). The management of mosquito borne diseases transmission mainly depends on the vector control programs. The information about the species prevalence and their habitat ecology are the key determining factors for implementing any vector control strategy. India has diverse environmental conditions facilitates diverse mosquito faunal composition throughout the country [2, 3].
The species composition varies depending on the ecological and geographical conditions of the area. For example, *Anopheles stephensi* and *Anopheles culicifacies* are typically known as urban and rural malaria vectors respectively. Besides, *Anopheles dirus*, *Anopheles sundaicus* and *Anopheles fluviatilis* prefers deep woodland, brackish waters, and forests respectively [4]. There are over 3,590 mosquito species globally whereas India exhibits over 410 mosquito fauna [5, 6, 7]. Studies on species composition and diversity of local mosquito population have helped in making efficient management strategies [8]. Such studies can form a baseline for mosquito-borne virus activity allowing monitoring due to variation over time.
Rajasthan lies to the western part of India which exhibits the arid climatic conditions. The present study was carried out in the two ecologically different regions of Rajasthan i.e., Kota and Barmer. Kota comes under the south-eastern area with 700 nm annual rainfall while Barmer located in the western part of the Rajasthan with annual rainfall ranging from 200-300 nm throughout the year.
In the present investigation attempts have been made to gather information about prevalent mosquito fauna in Kota and Barmer region of Rajasthan, India.

Materials and Methods Study area and sampling
The present study was carried out at Kota and Barmer districts of Rajasthan from January 2021 to December 2021.

Kota city is situated in the southeast of Rajasthan, near the banks of the Chambal River.It has a semi-arid environment with high temperatures throughout t h e year and covers an area around 527 km2. On the other hand, Barmer City is situated in the western region of Rajasthan and is surrounded by the Thar Desert with an area of 28,387 km2. It has humid climate conditions with 200–250 mm of annual rainfall [9, 10]. The different mosquito stages were collected using various sampling techniques during the survey. Adult stages were collected using BG- Sentinel traps and oral aspirators whereas immature stages were sampled through ladle (cap. 350 ml) and dipping techniques. For the collection of eggs of *Aedes* species, half water filled black plastic container (cap. 350 ml) with white filter paper was used as oviposition trap.

Preservation of specimens

Collected adult stages were anaesthetized using ethyl acetate and pinned in foam box whereas dead larvae and pupae were preserved in plastic vials containing 70% ethyl alcohol.

Identification

Barraud (1934) [11], Sirivanakarn (1976) [12], Das *et al*. (1990) [13] and Tyagi *et al*. (2015) [5] identification keys were used for the identification of various stages of different mosquito species.

Result and Discussion

Kota and Barmer region reported 3 species from the genus *Aedes* including *Aedes aegypti*, *Aedes albopictus* and *Aedes vittatus* belonging from 2 subgenera *Stegomyia and Fredwardsius*. Whereas, 9 and 7 species of the genus *Culex* from Kota and Barmer region respectively, were found which belongs to single subgenera *Culex*. Genus *Anopheles* was represented by 6 species in Kota region and 4 species in Barmer region which showed single subgenera *Cellia*. *Armigeres subalbatus* was the single species which recorded in both the region i.e., Kota and Barmer from subgenera *Armigeres* (Table 2 and 3). A total of 1450 species were reported from Kota region and 1258 species were collected from Barmer region. (Table 1).

Aedes species contributed 37.44% part of all mosquito species in the Kota region, with *Aedes aegypti* accounting for 17.86%, *Aedes albopictus* for 13.72%, and *Aedes vittatus* for 5.86%. Whereas *Culex* species represented 44.41% of total mosquito fauna in which *Culex quinquefasciatus* comprised of 31.44%, *Culex tritaeniorhynchus* 2.27%, *Culex annulus* 1.79%, *Culex gelidus* 2%, *Culex vishnui* 1.03%, *Culex pseudovishnui* 1.37%, *Culex vagans* 1.44%, *Culex edwardsi* 1.10% and *Culex whitei* 1.93% of total mosquito species. *Anopheles* species represented 13.31% of total mosquito species in Kota region, with *Anopheles subpictus* accounting for 3.03%, *Anopheles fluviatilis* 1.10%, *Anopheles sundaicus* 2.55%, *Anopheles stephensi* 4.55%, *Anopheles vagus* 0.68% and *Anopheles annularis* 0.75% of total mosquito fauna. *Armigeres subalbatus* represented 4.82% of total mosquito species in Kota region.

In the Barmer region, *Aedes* species made 34.49% of all mosquito species with *Aedes aegypti* accounting for 16.61%, *Aedes albopictus* for 12.63%, and *Aedes vittatus* for 5.24%. *Culex* species represented 50% of total mosquito fauna in which *Culex quinquefasciatus* comprised of 40.22%, *Culex gelidus* 2.62%, *Culex vishnui* 1.66%, *Culex pseudovishnui* 2.38%, *Culex vagans* 1.1% *Culex edwardsi* 0.79% and *Culex whitei* 1.19% of total mosquito species. *Anopheles* species represented 11.12% of total mosquito species in Barmer region, with *Anopheles subpictus* accounting for 2.38%, *Anopheles sundaicus* accounting for 3.17%, *Anopheles stephensi* accounting for 2.70%, and *Anopheles culicifacies* accounting for 2.86% of total mosquito fauna. *Armigeres subalbatus* contributed 4.37% of total mosquito species in Barmer region. *Culex quinquefasciatus* was the most abundant species in both Kota and Barmer region which comprised of 31.44% and 40.22% respectively.

Mosquitoes are poikilothermic in nature [14] and highly dependent on the prevalent native environmental conditions. Previous study reported significant difference between the desert (Jodhpur) and coastal (Kolkata) strains of *Aedes aegypti* for biological attributes such as survival and fecundity and suggested that desert strain followed more r-strategies than the coastal strain [15]. The present study reported that Kota region possess higher species richness and species diversity in comparison to the Barmer region. This might be due to the existing harsher environmental condition in Barmer region.

All the species that were collected throughout the survey have clinical importance. From the inspection site, significant vectors for diseases like dengue, chikungunya, yellow fever, Japanese encephalitis, and filariasis were identified. In India, *Aedes aegypti* and *Ae. albopictus* are the responsible vector species for dengue [16, 17] and chikungunya [18] whereas *Cx. quinquefasciatus*, *Culex tritaeniorhynchus* and *Cx. gelidus* found responsible for Japanese encephalitis [19] and Bancroftian filariasis [20]. Prevalence of higher species diversity of the genus *Anopheles* in Kota region indicates the higher possibility of malaria transmission in the area than the Barmer region. This can be possible as Kota has semi-arid condition and possess higher rainfall and better irrigation practices facilitates a greater number of *Anopheles* larval habitat than the Barmer region.

Table 1: Collected specimens from Kota and Barmer

Species	No. of specimens	
	Kota	Barmer
Aedes (Stegomyia) aegypti	259	209
Aedes albopictus	199	159
Aedes (Fredwardsius) vittatus	85	66
Culex (Culex) quinquefasciatus	456	506
Culex (Culex) tritaeniorhynchus	33	-
Culex (Culex) annulus	26	-
Culex (Culex) gelidus	29	33
Culex (Culex) vishnui	15	21
Culex (Culex) pseudovishnui	20	30
Culex (Culex) vagans	21	14
Culex (Culex) edwardsi	16	10
Culex (Culex) whitei	28	15
Anopheles (Cellia) subpictus	44	30
Anopheles (Cellia) fluviatilis	25	-
Anopheles (Cellia) sundaicus	37	40
Anopheles (Cellia) stephensi	66	34
Anopheles (Cellia) vagus	10	-
Anopheles (Cellia) annularis	11	-
Anopheles (Cellia) culicifacies	-	36
Armigeres (Armigeres)subalbatus	70	55
Total	1450	1258

Table 2: Diversity of mosquito species recorded in Kota region.

S. No.	Species name	Habitat positive for larval breeding												
		PC	CT	DT	MD	TH	RB	RP	PD	SP	SW	RF	CP	OAC
1.	*Aedes (Stegomyia) aegypti*	+	+	+									+	+
2.	*Aedes albopictus*	+	+	+		+								+
3.	*Aedes (Fredwardsius) vittatus*		+											
4.	*Culex (Culex) quinquefasciatus*								+	+	+			+
5.	*Culex (Culex) tritaeniorhynchus*				+		+		+				+	
6.	*Culex (Culex) annulus*						+	+						
7.	*Culex (Culex) gelidus*				+		+							
8.	*Culex (Culex) vishnui*				+		+							
9.	*Culex (Culex) pseudovishnui*				+		+							
10.	*Culex (Culex) vagans*				+		+							
11.	*Culex (Culex) edwardsi*				+		+							
12.	*Culex (Culex) whitei*				+		+							
13.	*Anopheles (Cellia) subpictus*											+	+	
14.	*Anopheles (Cellia) fluviatilis*											+	+	
15.	*Anopheles (Cellia) sundaicus*											+	+	
16.	*Anopheles (Cellia) stephens*i				+			+	+			+		
17.	*Anopheles (Cellia) vagus*							+	+			+	+	
18.	*Anopheles (Cellia) annularis*								+			+	+	
19.	*Armigeres (Armigeres) subalbatus*					+						+		+

Abbreviations: PC – plastic container, CT- Cement tank, DT- discarded tyres, MD – mud ditches, TH – Tree hole, RB – River beds, RP – Rock pool, PD – puddles, SP – Swimming pools, SW – Sewage water, RF – Rice field, CP – Clay pits, OAC – only adultcapture

Table 3. Diversity of mosquito species recorded in Barmer region.

S. No.	Species name	Habitat positive for larval breeding												
		PC	CT	DT	MD	TH	RB	RP	PD	SP	SW	RF	CP	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) stephens*i							+				+		
13.	*Anopheles (Cellia) sundaicus*							+				+		
14.	*Anopheles (Cellia) culicifacies*							+				+		
15.	*Armigeres (Armigeres)subalbatus*				+	+								+

Abbreviations: PC – plastic container, CT- Cement tank, DT- discarded tyres, MD – mud ditches, TH – Tree hole, RB – River beds, RP – Rock pool, PD – puddles, SP – Swimming pools, SW – Sewage water, RF – Rice field, CP – Clay pits, OAC – only adult capture

Conclusion

The study provides the information on species composition of mosquitoes in two different ecological regions of Rajasthan i.e., Kota and Barmer. The study reveals the presence of 19 mosquito species from Kota and 15 mosquito species from Barmer. The Barmer have shown lesser species diversity and richness than the Kota region. Both Kota and Barmer region have many dengue, chikungunya, malaria, Japanese encephalitis, and filariasis vector species, which highlights the need for vector surveillance measures to stop vector borne diseases in the areas.

Ethical approval

The present study does not involve any animal use therefore no ethical approval required.

Conflict of interest

The authors declare that they do not have any conflict of interest.

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