



Three Days Extensive Survey of Malaria, Dengue and Chikungunya Mosquitoes in The Capital of Rajasthan, India

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Abstract: The mosquito-borne diseases are transmitted among people by the bite of an infected mosquito. In India, the major mosquito vectors belong to three genera *Aedes*, *Anopheles* and *Culex*. The mosquito-borne disease transmission dynamics is ruled by a series of various type of factors like changes in climatic conditions, and other man-made factors like different types of land use, community hygiene and their behaviors etc. The presence of mosquitoes is a major concern for public health due to possibility of transmitting arboviral diseases like malaria, dengue and chikungunya; which repeatedly occurs in India and cause substantial morbidity and mortality annually. Current study was carried out in Jaipur district to determine the larval density, breeding preference and relative abundance of *Anopheline* and *Aedes* mosquitoes during October month of 2021 because there is less information available regarding vector breeding preference and other associated factors in surveyed areas. Survey was carried out in various place of Jaipur district [Chand Pole, Chhoti Chopad, Mahal Road, Jagatpura and Chaksu (Kothun)]. Total 185 houses were surveyed, among them 140 houses were found positive for *Aedes* and *Anopheline* mosquitoes. The larval indices like House Index (HI), Container Index (CI), Breteau Index (BI) and Pupae Index (PI) were calculated as 75.67%, 46.89%, 142.70 and 25.94 respectively. Total 46.89% of inspected containers were found positive for mosquitoes' immature stages. The cattle drinking tanks were found as the most suitable breeding container with 82.75% positivity. This study concludes that *Aedes aegypti*, *Aedes albopictus* and *Anopheles stephensi* was found as the most abundant mosquito in this region so this area at high risk for mosquito-borne disease. The study recommends that the surveillance program regarding vector ecology and biology should be carried out in this area and an awareness program should be also conducted regarding vector and their breeding preferences.

Keywords: Public health, dengue, vector, malaria, *Aedes*, *Anopheles*

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1. INTRODUCTION

In the tropical climatic areas, approx. 3500 mosquito species were found abundantly. Mosquitoes are widely distributed in all different types of geographical regions at the global level excluding areas near the two poles and more than 2000 feet high altitude regions. Mosquitoes are small insects measuring about 4 to 6 mm and consisting in the family Culicidae. The female mosquitoes need blood for their egg development so they suck the blood from a wide range of hosts including humans. They have public health importance due to the capability of transmitting the deadliest and life-vulnerable arboviral diseases malaria, dengue, chikungunya, bancroftian filariasis and zika fever which cause mortality, morbidity, and socioeconomic loss.^{1,2} The Culicidae family consists of 13 genera among them the *Aedes* are marked as the most dangerous mosquito due to its public health threat at the global level. Mosquitoes are distributed worldwide³ in tropical and subtropical regions including India. In the dengue-endemic regions, the *Aedes aegypti* was categorized as a major dengue vector. The *Aedes albopictus*⁴ has also been incriminated in dengue disease transmission in dengue-endemic regions.⁵⁻⁶ Mostly the *Aedes aegypti* prefer to breed in small domestic containers⁷ including various types of discarded receptacles, buckets, mud pots, discarded tires⁸ and sinks.⁹ They are found in almost all types of microhabitats and are adaptable to breed in different types of water bodies like-polluted and clean small water bodies, mangrove swamps, paddy fields, rivers, streams, grassy ditches, temporary rain pools,¹⁰ buckets, discarded tires,¹¹ plastic container, mud pots and different type of tanks. The developmental activities like mining, irrigation, poor drainage and road construction provide the favorable breeding sites that accelerate the problem of Vector-Borne Diseases.¹¹⁻¹⁴ The increasing number of new developments of transportation accelerate the workers migrations and these expose humans to new areas that are directly influencing the dengue disease outbreaks.¹⁵⁻¹⁶ The mosquito's density fluctuates with climatic factor like humidity, temperature and rainfall. The mosquito borne disease outbreaks generally occur in monsoon and post-monsoon season.¹⁷ *Aedes aegypti* acts as dominant species and is distributed in a wide range of geographical areas including temperate and tropical climatic zones. For the determination of the distribution pattern and

abundance of mosquitoes the local climatic parameters play as a key role. The distribution of mosquito borne disease are controlled by the tolerance capacity (climatic conditions) of their vectors. Water is vital things for mosquito breeding because mosquitoes breed in water, further their larval and pupal stages are also aquatic. Mosquitoes have a wide range of breeding sites including small tree-holes to large waterbodies like ponds, lakes etc. Mostly, all mosquito larvae prefer stagnant water bodies. Some mosquitoes breed in fresh water bodies whereas some breed in sewage water. The humans are directly or indirectly responsible for proliferation of malaria and dengue mosquitoes near human dwelling areas.¹² Small artificial containers are most favorable for *Aedes* spp. breeding near human dwelling areas.¹⁸ The study regarding vector distribution, breeding, resting behavior and ecology plays as major role in vector control strategies. Source reduction is an effective method of reducing mosquitoes' density by destroying the larvae number.¹⁹ The study regarding vector biology and larval ecology have been played an important role in mosquitoes' control programs.^{20,21} There is a lack of information available regarding vector biology and larval ecology in the Jaipur district of Rajasthan state. This study will reveal mosquito distribution patterns, breeding preferences, and vector host preferences and also will help to estimate the risk factor for arboviral disease outbreaks. It will help in the eradication of mosquito breeding sites nearby human dwelling areas that will also help in reducing dengue and malaria outbreak.

2. MATERIALS AND METHODS

2.1. Site Selection

The three days mosquito larval survey was conducted from 12-14 October 2021 in Jaipur district of Rajasthan state, India. The Jaipur district is situated at an altitude of 431 meters and 1417 feet above sea level. The relative temperature of this area remains high throughout the year and has semi-arid-type climates. The three sides of Jaipur district are covered by Aravalli Hills which provides favorable climatic conditions to flourish mosquito-borne diseases in these areas. The study sites were selected on the basis of reported positive cases in that particular area (Figure 1 & Figure 2).

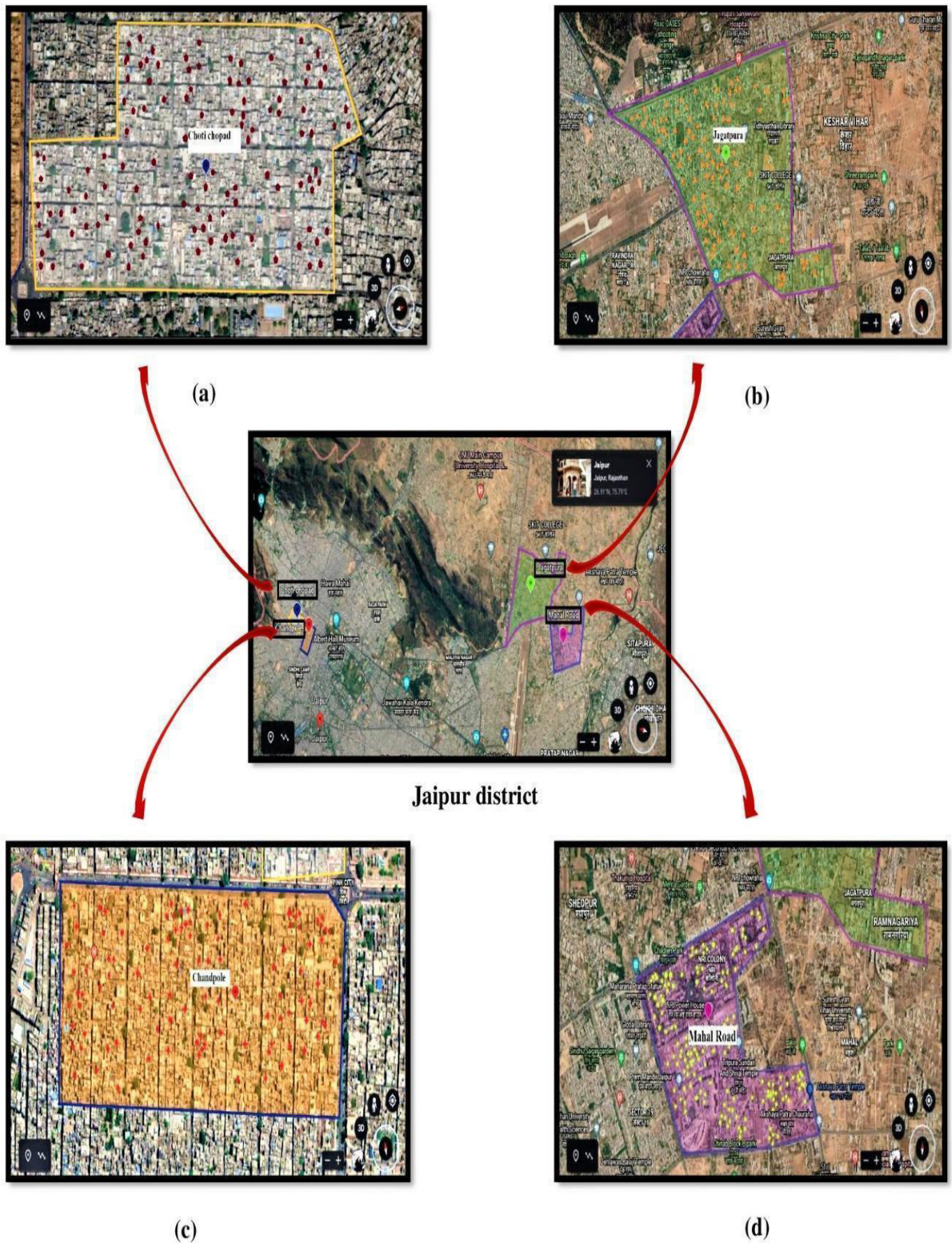


Fig 1: Map of Jaipur district and different types of surveyed areas (a) Choti chopad (b) Jagatpura (c) Chandpole & (d) Mahal Road (different types of color dots represent the containers found positive for mosquitoes' breeding)

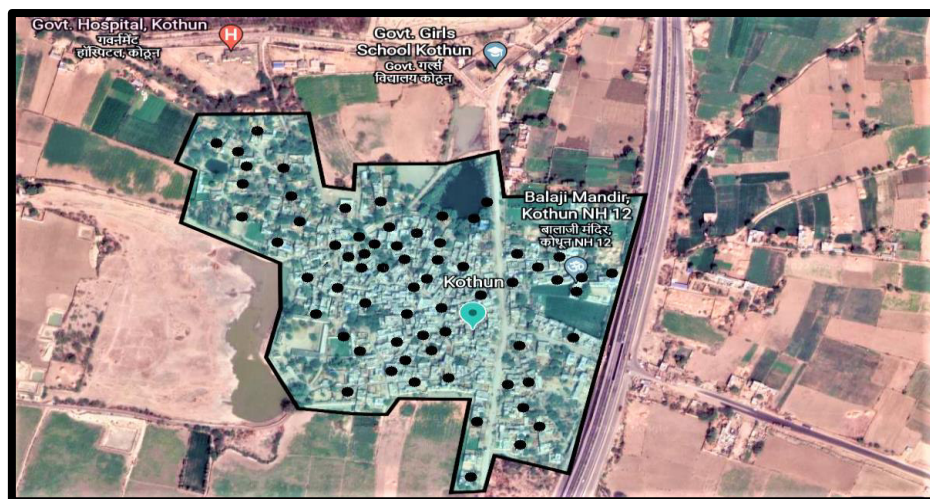


Fig 2: Surveyed area Kothun (rural area of Jaipur district in which the black dot represents the containers found positive for mosquitoes' breeding)

2.2. Larval Collection

Mosquitoes' larvae were collected randomly from various sites in Jaipur district (Chand Pole, Chhoti Chopad, Mahal Road, Jagatpura and Chaksu (Kothun). During this survey the different sites were searched including outdoor places and residential areas. In these areas the different type of water-bodies i.e., cattle drinking tanks, cemented tanks (overhead and underground tanks), discarded tires, discarded sinks, mud pots, plastic bowls, flower pots, metallic bowls, plastic drums, buckets and coolers were checked for the presence of larvae & pupae of malaria and Dengue vectors. These collections were carried out using trays, pipettes, droppers, sieves and dippers (250 ml capacity) from different types of water bodies. Open water reservoir, big water drum and underground water tank are large water bodies so it's very hard to collect larvae from these water bodies. For this, the dipper and sieves were used to collect the larvae from these water bodies. The larvae were taken into small plastic wide-mouthed bottles labeled with place & date, type of water etc. To prevent mortality of these larvae & pupae, the collection bottles were kept empty at least 3-5 cm for proper respiration. These larval and pupal collections were transported immediately as possible to the laboratory of Public Health Entomology for the emergence of adult mosquitoes and their further morphological identification.

2.3. Adult Collection

Adult mosquitoes were collected by mouth aspirators from different types of habitats in these surveyed areas. Mosquitoes' collections were carried out in the early morning from their resting sites. The collected mosquitoes were transported immediately to the laboratory, and provided glucose solution to feed them.

2.4. Identification Of Mosquitoes

Emerged and collected adult mosquitoes were identified by using "Pictorial Identification key for Indian Anophelines"²² & "Indian Anophelines"²³ and taxonomic key of "ZOOTAXA 589- key for the identification of mosquitoes (Diptera: Culicidae) associated with dengue virus transmission" for *Aedes* mosquitoes.²⁴

2.5. Data Analysis

With the help of collected data, the risk factors (House Index (HI), Container Index (CI), Breteau Index (BI) and Pupae Index (PI)) of these areas were calculated using the following formulas:

$$\text{House Index (HI)} = \frac{\text{No. of house positive with Aedes larvae and pupa}}{\text{Total no. of house searched}} \times 100$$

$$\text{Container Index (CI)} = \frac{\text{No. of water containers found positive with Aedes larvae}}{\text{Total no. of container searched}} \times 100$$

$$\text{Breteau Index (BI)} = \frac{\text{No. of water containers found positive with Aedes larvae}}{\text{Total no. of house searched}} \times 100$$

$$\text{Pupae Index (PI)} = \frac{\text{No. of Pupae collected from positive containers}}{\text{Total no. of house searched}} \times 100$$

3. RESULT

During this survey, a total of 185 houses, and their nearby areas were surveyed for the presence of mosquito immature stages, out of them 140 houses were found positive for the dengue mosquito larvae. There is a total number of 563 containers were inspected among them, 264 containers were found positive for mosquito larvae with 46.89% positivity. Cattle drinking tanks were found as the most dominant breeding container with 82.75% positivity followed by bird

drinking bowls (59.57%), coolers (60.00%), discarded tires (57.77%), plastic bowls (54.54%), flowerpots (29.03), plastic drums (25.00%), metallic bowls (22.22%), mud pots (16.66%), discarded sinks (12.50%), buckets (7.89%) and underground tanks (4.76%) whereas the overhead tanks were found negative for mosquito breeding (Table 1; Figure 3). Anophelines and Aedes mosquitoes were also observed sharing the same microhabitat and breeding sites.

Table-1: Container breeding preferences of mosquitoes in Jaipur District of Rajasthan

| Type of container | No. of container inspected | Number of positive containers (%) | Type of collected mosquitoes |
|-----------------------|----------------------------|-----------------------------------|------------------------------|
| Cooler | 15 | 09 (60.00) | Aedes |
| Plastic drum | 32 | 08 (25.00) | Aedes & Anopheles |
| Buckets | 38 | 03 (07.89) | Aedes |
| Plastic bowl | 22 | 12 (54.54) | Aedes |
| Metallic bowl | 18 | 04 (22.22) | Aedes |
| Mud pot | 06 | 01 (16.66) | Aedes |
| Flower pot | 62 | 18 (29.03) | Aedes & Anopheles |
| Discarded Tire | 45 | 26 (57.77) | Aedes |
| Discarded sink | 08 | 01 (12.5) | Aedes |
| Cattle Drinking tanks | 116 | 96 (82.75) | Aedes & Anopheles |
| Bird Drinking Bowls | 141 | 84 (59.57) | Aedes & Anopheles |
| Underground Tanks | 42 | 02 (04.76) | Aedes |
| Overhead Tanks | 18 | 00 (00.00) | - |
| Total | 563 | 264 (46.89) | - |

The House Index (HI), Container Index (CI), Breteau Index (BI) and Pupae Index (PI) were estimated as 75.67%, 46.89%, 142.70 and 25.94 respectively, which indicated that, surveyed areas were at the high risk for arboviral disease outbreaks (Table 2). In Jaipur district, *Anopheles stephensi*, *Anopheles barbirostris*, *Anopheles annularis*, *Anopheles subpictus* (*Anopheles spp.*), *Aedes aegypti* and *Aedes albopictus* (*aedes spp.*) were found prevalent. Among total number of collected mosquitoes,

Aedes aegypti are found as most abundant species among emerged adult mosquitoes with 37% followed by *Aedes albopictus* (27%), *Anopheles stephensi* (17%), *Anopheles barbirostris* (9%), *Anopheles subpictus* (6%), and *Anopheles annularis* (4%) (Figure 4). *Aedes aegypti* and *Aedes albopictus* were found in close association that may be increase dengue disease outbreak in this area.

Larval indices

Table 2: Risk categorization of clusters according to larval indices

| | |
|----------------------|--------|
| House index (HI) | 75.67% |
| Container index (CI) | 46.89% |
| Breteau index (BI) | 142.70 |
| Pupae Index (PI) | 25.94 |

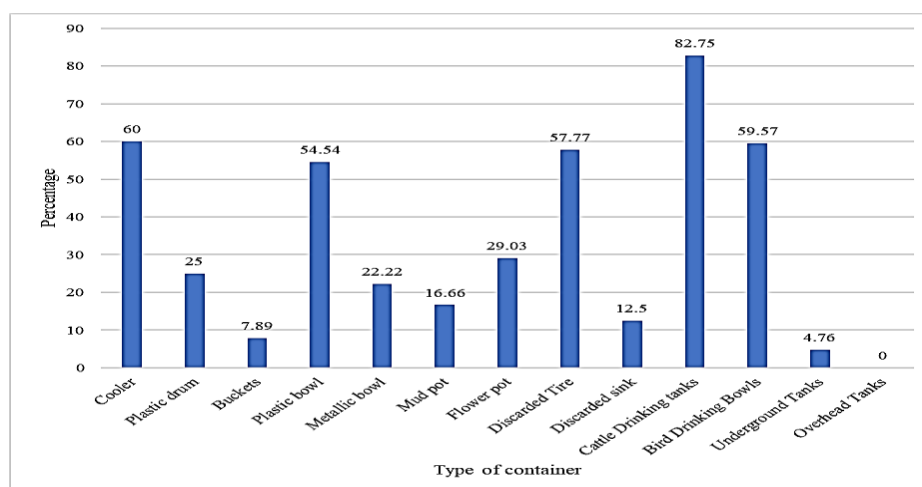


Fig 3: Percentage of various types of positive containers found with immature stages of mosquito's in Jaipur District of Rajasthan

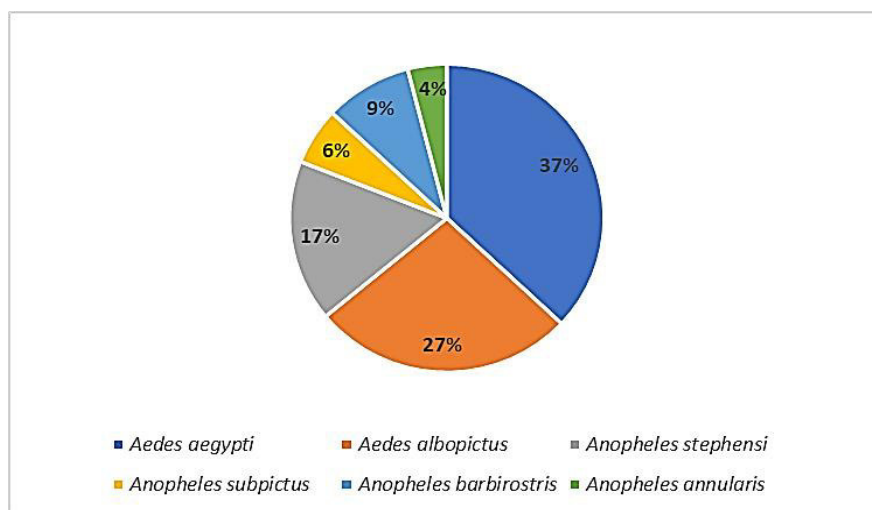


Fig 4: Relative abundance (%) of mosquitoes after adult emergence of larvae during larval collection in Jaipur district

4. DISCUSSION

Study revealed that cattle drinking tanks, coolers, bird drinking bowls and plastic bowls are the most favorable and effective habitats for vector breeding. In the Jaipur district, most of the people are habituating to storing water indoors in different containers because this area is facing water shortage problems for several years. Actually, these water containers mostly remain open or not fully covered, so, these could have served as mosquito breeding sites in these areas. In urban areas, the disposed of unwanted containers also served as breeding sites and became the cause of disease outbreaks in these areas.¹⁰ During this survey, the mosquito's abundance was found high due to the availability of various types of breeding sites, human hosts, and other favorable climatic conditions. It is also observed that the *Aedes* and *Anopheles* mosquitoes were also sharing their breeding habitats due to the preference for the same microclimate in any breeding sites. Generally, *Aedes aegypti* was considered as primary vector for dengue and dengue hemorrhagic fever^{25,26} whereas *Aedes albopictus* as secondary vector.²⁷ *Aedes aegypti* is a competent vector for arboviral diseases due to its anthropophilic nature and high frequency of bites.²⁵ *Aedes aegypti* is adapted to human dwelling areas and mostly prefer urban area whereas *Aedes albopictus* prefer vegetation areas.²⁸⁻³⁰ During this study the *Aedes aegypti* and *Aedes albopictus* were found highly abundant in urban areas due to presence of favorable microclimatic conditions, easy access to exposed host body and vegetation also; it predicts that Jaipur people are at high risk of arboviral diseases. Similarly, in Kerala, both species were also found in association because the urban and rural areas both are having thick vegetation and favorable climatic conditions.¹⁶ Generally, anopheline mosquitoes breed in clean and unpolluted water. In our study, it is observed that *Aedes aegypti* and *Aedes albopictus* are breed in various types of artificial containers (discarded sinks, discarded tires, small plastic cups and containers, metallic bowls, mud pots, coolers) in Jaipur district; this type of same observation has been observed by Thavara et al.,³¹ Chen et al.,³² Preechaporn et al.,³³ and Thenmozhi et al.,³⁴ in their study. In our study the all type of water bodies (Fresh clear water-opaqueness free, turbid water-containing suspended foreign particles & sedimented and polluted water-containing oil particles & wastes) are surveyed for mosquitoes breeding and observed that all type of *Aedes* and *Anopheles* species prefer fresh water to breed compare then turbid and polluted water but it is totally depended on availability of water bodies; similar observation reported by Lee and Hishamudin³⁵

and Chen et al.,³⁶ in their study. Malaria and dengue vectors are also found to breed in cemented tanks and other containers in Jaipur district. In Kolkata, it was also reported that anopheline mosquitoes breed in containers i.e., tin cans, battery shells, tiers and bitumen drums.³⁷ Various similar studies have reported that anthropogenic and developmental activities provide temporary breeding sites i.e., hoof prints, rice paddy, tracks and tiers for anopheline mosquitoes.^{1,5,38,39} In our study, mixed breeding of the *Aedes aegypti* and *Aedes albopictus* was observed in the study area and similar observations were also reported by several scientist in their study.^{28-30,40}

5. CONCLUSION

This study revealed that the *Aedes aegypti*, *Aedes albopictus* and *Anopheles stephensi* are the most abundant and prevalent species in the Jaipur district which are vectors of dengue and malaria disease respectively; it suggests that this area is at high risk for mosquito-borne diseases and recommends to carry out in-depth research regarding vector biology and their surveillance in the area. Most of the time it has been observed that anopheline and aedes mosquitoes are sharing their habitat in man-made breeding sites, so it shows the sympatric association of both kinds of mosquitoes. The cattle drinking tanks were found as most favorable breeding containers for both malaria and dengue mosquitoes, so this study also recommends that antilarval and fogging activity should be carried out by the municipal corporation of Jaipur and also suggest that a public health awareness program should be organized to impart the knowledge regarding potential breeding sites, their life-cycle and proper disposal of unwanted containers.

6. AUTHOR CONTRIBUTION STATEMENT

Dr. Arti Prasad and Dr. Devendra Kumar conceptualized and designed the study methodology. Mr. Saha Dev Jakhar and Mr. Ajay Kumar Kumawat collect the data and analyzed them. Dr. Ashok Kumar and Mr. Saha Dev Jakhar put valuable input in designing manuscript. All authors read and gave their input to prepare the manuscript.

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8. CONFLICT OF INTEREST

Conflict of interest declared none

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