Bulletin of Pure and Applied Sciences
Vol.40A (Zoology), No.2,
July-December 2021: P.238-249

Print version ISSN 0970 0765
Online version ISSN 2320 3188
DOI: 10.5958/2320-3188.2021.00028.0

Content Available online at: https://www.bpasjournals.com/zoology

Original Research Article

Surveillance of Dengue Vector, *Aedes aegypti* (L.) Mosquitoes in Udaipur District of South Rajasthan (India)

***Ashok Kumar[1], Arti Prasad[2]**

Author's Affiliation:
[1]Research Associate, Department of Zoology, University College of Science, Mohanlal Sukhadia University, Udaipur, Rajasthan 313001, India
E-mail: ashokdagur198987@gmail.com
[2]Prof. & Head, Department of Zoology, University College of Science, Mohanlal Sukhadia University, Udaipur, Rajasthan 313001, India
E-mail: artimlsu@yahoo.co.in

***Corresponding author:**
Ashok Kumar
Research Associate, Department of Zoology, University College of Science, Mohanlal Sukhadia University, Udaipur, Rajasthan 313001, India

E-mail: ashokdagur198987@gmail.com

Article Info:
Received on 17.05.2021
Accepted on 31.08.2021
Published on 15.12.2021

ABSTRACT:
Mosquito borne diseases are the most considerable public health risks globally. Dengue fever infection is one of the most important arboviral diseases in humans which are transmitted by Aedes aegypti (L.) mosquitoes. These Aedes aegypti (L.) mosquitoes are highly persistent and can survive almost any climatic conditions. Therefore, an entomological survey was undertaken during 2015 to 2018 to evaluate the entomo-epidemiological risk of Aedes aegypti (L.) mosquito borne diseases (VBD) in Udaipur district of South Rajasthan to diminish potential global health risks and prevent introduction of new vector borne diseases (VBD). A cross-sectional immature stage survey was done indoors in Region-I (Urban areas), Region-II (Periurban areas) and Region-III (Rural areas) of Udaipur in 3645 houses. Mosquito larval sampling was conducted using sieves, pipette, dipper or depending on container types. Larvae were recognized morphologically and larval indices were also considered. Repeated surveys were undertaken in Urban, Periurban and Rural areas of Udaipur. A total of 8733 containers were inspected, and of these 1284 were positive for Aedes aegypti (L.) mosquito larvae. Coolers, Plastic Drums, Tires, Flower Pots, Mud Pots and Discarded Buckets were most favourable for breeding. All the entomological indices were found to be above the critical level for all selected areas, prescribed by WHO, (2003; 2011). The larval indices i.e. House Index (HI), Container Index (CI), Breteau Index (BI) and Pupae Index (PI) varied from 10.20% to 11.76%, from 12.84% to 16.65%, from 31.85 to 41.89 and from 32.42 to 45.02 respectively. The Periurban areas were found to be more prone to mosquito breeding compare to other both areas (Urban and Rural). To control these Aedes aegypti (L.) mosquitoes, a careful and regular invigilation of the study areas is recommended.

Keywords: *Dengue, Dengue Vector, Aedes aegypti (L.), Periurban areas, Containers, House Index (HI), Container Index (CI), Breteau Index (BI) and Pupae Index (PI).*

How to cite this article: Kumar, A., & Prasad, A., & (2021). Surveillance of Dengue Vector, *Aedes aegypti* (L.) Mosquitoes in Udaipur District of South Rajasthan (India). *Bulletin of Pure and Applied Sciences-Zoology,* 40A (2), 238-249.

INTRODUCTION

Mosquito-borne diseases are the most noteworthy public health risks worldwide. Dengue fever infection is one of the most important arboviral diseases in humans transmitted by *Aedes* mosquitoes. It is widespread in Africa, America, eastern Mediterranean, South East Asia, and the Western Pacific, threatening more than 2.5 billion people (Webb, 2008; Guillena et al., 2010). *Aedes* is a genus of mosquitoes initially found in tropical and subtropical zones. It is considered highly invasive in nature and can transmit a variety of pathogens that can be transmitted to humans. The species *Aedes aegypti* (L.) and *Aedes albopictus* (Skuse) are the principal vectors of concern worldwide. *Aedes aegypti* (L.) mosquito is the chief vector that transmits the viruses that cause dengue. It is also transmit chikungunya, rossriver viruses, yellow fever, avian parasite, *Plasmodium gallinaceum,* filarial infections of *Wuchereria bancrofti* and *Dirofilaria immitis* (Russell et. al., 2005) that has become adapted to urban, periurban or suburban and rural human environments.

Geographic distribution of dengue has extended worldwide in the past five decades. Dengue, mosquito borne acute disease is now endemic in>100 countries, with an estimated 400 million infections each year (Bhatt et al., 2013). World Health Organization currently estimates that the incidence of dengue has increased 30-fold over the last 50 years 50–100 million cases of Dengue infections occur worldwide every year, putting almost half of the world's population at risk (WHO, 2017).

In India dengue is widespread and endemic in most major cities namely as Andhra Pradesh, Goa, Gujarat, Haryana, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Punjab, Rajasthan, Tamil Nadu, Uttar Pradesh, West Bengal, Chandigarh, Delhi and Panduchery. According to National Vector Borne Disease Control Programme (NVBDCP) data, the number of cases reported in 2018 was about 101192 for dengue with 172 deaths while in 2019, 157315 with 166 deaths India (National Vector Borne Disease Control Programme, 2020). Rajasthan is geographically an arid region where dengue cases are observed in a regular manner. There was exponential increase in dengue cases in 2015. Ajmer, Kota, Tonk and Udaipur had the highest burden, followed by Jaipur and Rajsamand. Unexpectedly, five districts, i.e., Chittorgarh, Bhilwara, Jhalawar, Pali and Sirohi, did not report a single probable case of dengue during 2015, but laboratory confirmed cases were reported from these districts, except Sirohi and Pali district (Rathore et al., 2018).

The dengue vaccine is still in development process and is unlikely to be obtainable in the near future. In recent days, emergence and development of insecticide resistance in dengue vectors, especially in *Aedes aegypti* (L.) are main barriers vector control programs. The resistance to organophosphates and pyrethroids has been reported since the 1980s and 1990s respectively (Ranson et al., 2010). All *Aedes aegypti* (L.) populations have become resistant to temephos, deltamethrin and other insecticides also at many places but mostly susceptible to *Bacillus thuringiensis israelensis* (Bti). This resistance has recently been shown to be negatively impacting on the efficacy of vector control interventions taken together, so it is necessary to calculate susceptibility status of vectors against insecticides before applications of insecticides (Scholte et al., 2006; Prasad and Kumar, 2020).

Currently, the only method to effectively control dengue is to control the mosquito vectors, especially *Aedes aegypti* (L.). Diurnal behavior of *Aedes aegypti* (L.) and the propensity to oviposit in small water-holding containers, especially in areas that are temporary or are located inside houses, limits this vector's availability for large scale sampling. Specified the biological and behavioral characteristics of *Aedes aegypti* (L.), trapping eggs or adult mosquitoes would be a more efficient way of identifying the temporal and spatial placement of interventions that would prevent disease outbreaks or lessen their strength (Favaro et al., 2008; Morrison et al., 2008).

The incidences of vector-borne diseases are increasing terrifyingly due to the emergence of resistance against various insecticides and potential environmental issues associated with some synthetic insecticides such as DDT, globalization, uncontrolled and unplanned urbanization creating mosquitogenic, developmental activities, poor environmental sanitation, and human behavior relating to water collection widespread travel both within the country and across borders, conditions for the vector mosquito populations has indicated that supplementary approaches to control the propagation of mosquito population would be an vital priority (Grodner, 1997; WHO, 2011).

Since South Rajasthan is a tribal dominated hilly zone of state and vector borne diseases are much prevalent. Udaipur district has been endemic for dengue, having incidence recorded throughout the year. During the year 2015, total 33 dengue cases (In Urban and Periurban areas- 19, and in Rural areas- 14) were confirmed by ELISA method, in year 2016 total cases were as 15 (In Urban and Periurban areas- 06 and in Rural areas- 09) and in year 2017, 28 cases (In Urban and Periurban areas- 14, and in Rural areas- 14), in year 2018, 74 cases (In Urban and Periurban areas- 44 and in Rural areas- 30) and in year 2019 total 228 cases were confirmed, out of which 86 reported from Urban and Periurban areas and 142 from Rural areas of Udaipur district of South Rajasthan (Source: Office of the Chief District Medical Officer, Udaipur).

Hence, the aim of this study was to determine the distribution and abundance of dengue vector *Aedes aegypti* (L.) mosquitoes in a dengue endemic site in the Udaipur district of South Rajasthan and also monitor the susceptibility of study area for dengue disease. Distribution and abundance data of dengue vector *Aedes aegypti* (L.) have not been recorded before in Study area, so our study will be one of the pioneer studies to control dengue vector *Aedes aegypti* (L.), for vector control programs of National Vector Borne Disease Control Programme (NVBDCP) and others also.

MATERIAL & METHODS

Study Area

Present entomological surveillance was undertaken in and around the Udaipur district of South Rajasthan from year 2015 to 2018. Udaipur district is one of the 33 districts of Rajasthan in India that lies between 23°46’ and 25°5’ north latitudes and 73°9’ and 74° 35’ east longitude with an average elevation of 598.00 meter (1,962 feet) and total area 64 km^2. Udaipur district is generally hilly. A door-to-door cross-sectional entomological survey was carried out in houses and peridomestic areas to perceive mosquito larval breeding sites with a view to study the level of infestation of areas with *Aedes aegypti* (L.) larvae (Figure 1). The weather of study area of the year is hot and humid throughout the day and night.

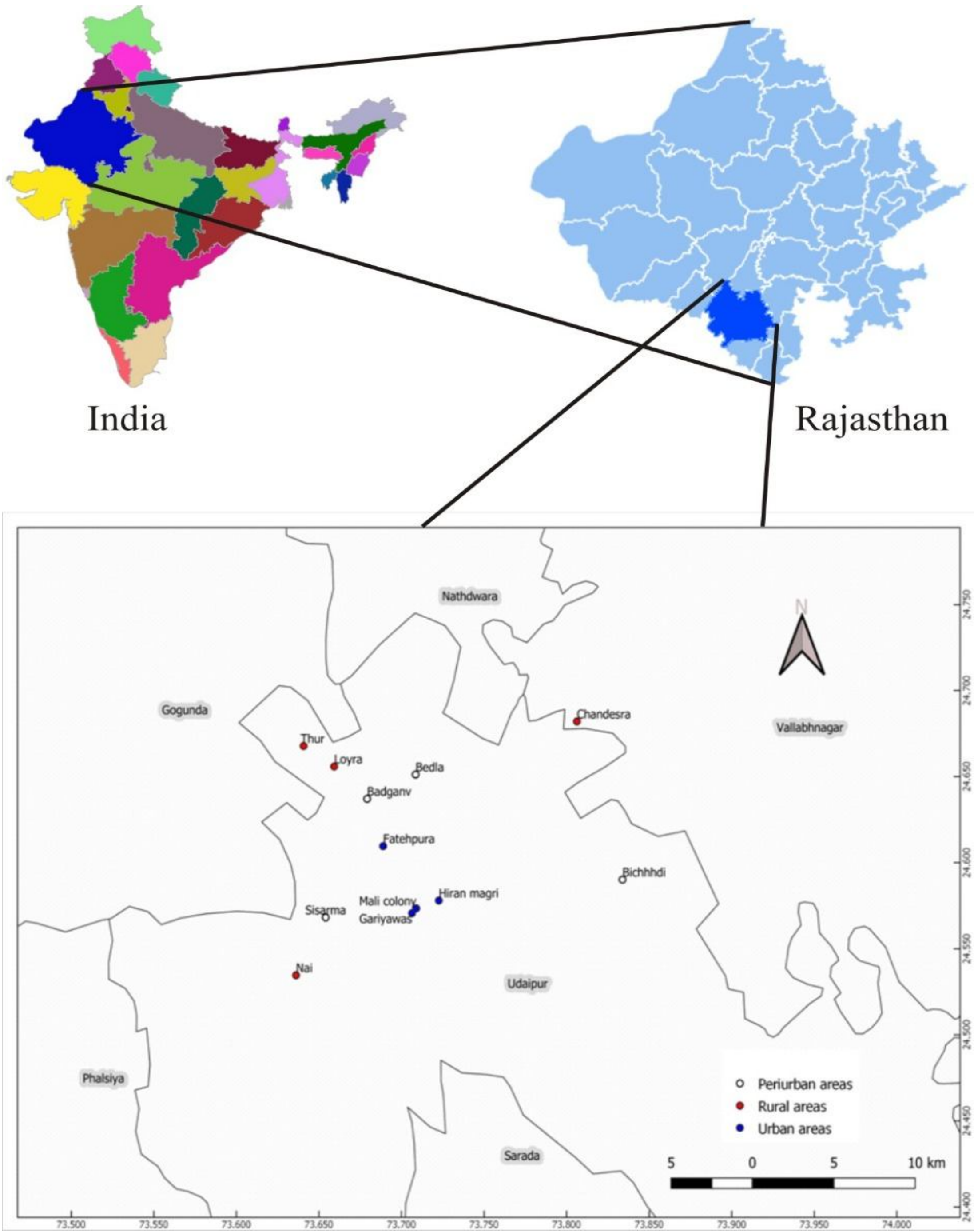


Figure 1: Sample collection sites of Study area (Udaipur district of South Rajasthan)

Entomological Surveillance

The entomological surveillance of *Aedes aegypti* (L.) mosquito has been standardized on different indices based on simple determination of presence or absence of *Aedes aegypti* (L.) larvae either in each water container or rather in each house (Tun-Lin et al., 1996; Focks, 2003). House index (HI) which is percentage of houses positive for larvae, Container index (CI) that is percentage of containers positive for larvae, Breteau index (BI) i.e., number of positive containers per 100 houses and Pupae index (PI) defined as number of pupae collected in infected containers from searched houses were calculated.

Surveillance was conducted for three years (2015 to 2018) in three selected seasons- Premonsoon, Monsoon and Postmonsoon in three type regions/ areas i.e. Region-I (Urban areas), Region-II (Periurban areas) and Region-III (Rural areas) with the selection of four villages or colonies of each area. Larval and pupal collection was carried out three times in each season at each selected spot with the help of trays, plastic cups, pipettes, droppers, sieves and dippers (250 ml capacity). All water-holding containers were examined. Either the name/type of the containers namely as Coolers, Underground Cemented Tanks, Cemented Tanks, Plastic Drums, Discarded Buckets, Plastic Bowls, Metallic Bowls, Mud Pots, Flower Pots, Tires, Cattle Drinking Tanks and Bird Drinking Bowls. The water of narrow mouth was sucked up with the pipette. Small containers (<20 liter capacity) were completely drained through a strainer into a larval sampling tray to collect larvae and pupae. Larger containers were sampled using a 250 ml larval dipper. Three dips were taken from the surface water. The larvae and pupae were taken into small plastic wide-mouthed bottles having air in the top 1-2 cm, labeled with type of water bodies, places and date and brought to insectary of Laboratory of Public Health Entomology, Department of Zoology, Mohanlal Sukhadia University, Udaipur, Rajasthan, India for rearing and adult emergence. Emerged adults were carefully identified under a microscope, using taxonomic key of “Pictorial key for the identification of mosquitoes (Diptera: Culicidae) associated with dengue virus transmission” given by of Reuda (2004).

Figure 2: ***Aedes aegypti*** **(L.) mosquito larvae and pupae breeding in various containers: (A) Cooler, (B) Underground Cemented Tank, (C) Cemented Tank, (D) Plastic Drum, (E) Discarded Bucket, (F) Plastic Bowl, (G) Metallic Bowl, (H) Mud Pot, (I) Flower Pot, (J) Tire, (K) Cattle Drinking Tank and (L) Bird Drinking Bowl**

Data Analysis

For calculation of risk factors of an area following calculations were done for the collected Surveillance data-

House Index (HI) $= \frac{\text{No.of house possitive with Aedes larvae and pupa}}{\text{Total no.of house searched}} X100$

Container Index (CI) $= \frac{\text{No.of water containers found possitive with Aedes larvae}}{\text{Total no.of container searched}} X100$

Breteau Index (BI) $= \frac{\text{No.of water containers found possitive with Aedes larvae}}{\text{Total no.of house searched}} X100$

Pupae Index (PI) $= \frac{\text{No.of Pupae collected from positive containers}}{\text{Total no.of house searched}} X100$

Statistical Analysis

Larval survey data of different breeding sites based on the name/type of the containers (namely, Coolers, Underground Cemented Tanks, Cemented Tanks, Plastic Drums, Discarded Buckets, Plastic Bowls, Metallic Bowls, Mud Pots, Flower Pots, Tires, Cattle Drinking Tanks and Bird Drinking Bowls) was analyzed. Plain vanilla probabilistic test to judge the significance of chance of getting positive containers (i.e., containers contain single *Aedes aegypti* (L.) larvae) in different areas were applied. For all areas different entomological indices (namely as HI, CI, BI, and PI) were calculated.

RESULTS

In entire survey from 2015 to 2018, a total of 3645 houses were surveyed for the presence of artificial breeding containers for *Aedes aegypti* (L.) mosquitoes. Out of these 421 houses (143 in Region-I (Urban areas), 154 in Region-II (Periurban areas) and 124 in Region-III (Rural areas)) were found to contain positive containers. Maximum house infested with vector was found in Region-II (Periurban areas). Overall 8733 artificial containers were inspected among which maximum infected containers were found in Region-II (Periurban areas) (509) where as minimum in Region-III (Rural areas) (387) containers were found positive for mosquito larvae and pupae (Graph 1).

The most of the breeding was detected in coolers. Various breeding containers searched were Coolers, Underground Cemented Tanks, Cemented Tanks, Plastic Drums, Discarded Buckets, Plastic Bowls, Metallic Bowls, Mud Pots, Flower Pots, Tires, Cattle Drinking Tanks and Bird Drinking Bowls. Percentage positivity of mosquito breeding in different containers in Urban, Periurban and Rural areas of Udaipur district of South Rajasthan were shown in Table: 1 & Figure: 2. Among these different containers, coolers showed most favourable breeding sites in all areas with overall probability of (24.03%), whereas metallic bowls showed least favourable for breeding (10.24%) (Table 1). Although other containers i.e. Plastic Drums, Tires, Flower Pots, Mud Pots and Discarded Buckets were also found favourable for *Aedes aegypti* (L.) mosquitoes breeding.

The outcomes of the commonly used larval indices (house index, container index, breteau index and pupae index) are depicted in Table: 2. HI, CI, BI and PI ranged between 10.20% and 11.76%, between 12.84% and 16.65%, between 31.85 and 41.89 and between 32.42 and 45.02 respectively, at different locations in the Udaipur district. Region-II (Periurban areas) showed highest HI (12.67%), CI (16.65%) and BI (41.89) followed by Region-I (Urban areas) and Region-III (Rural areas). These indices showed that there was high infestation of artificial water containers by mosquito immature stages (larvae and pupae) which may cause an outbreak of dengue (Table 2).

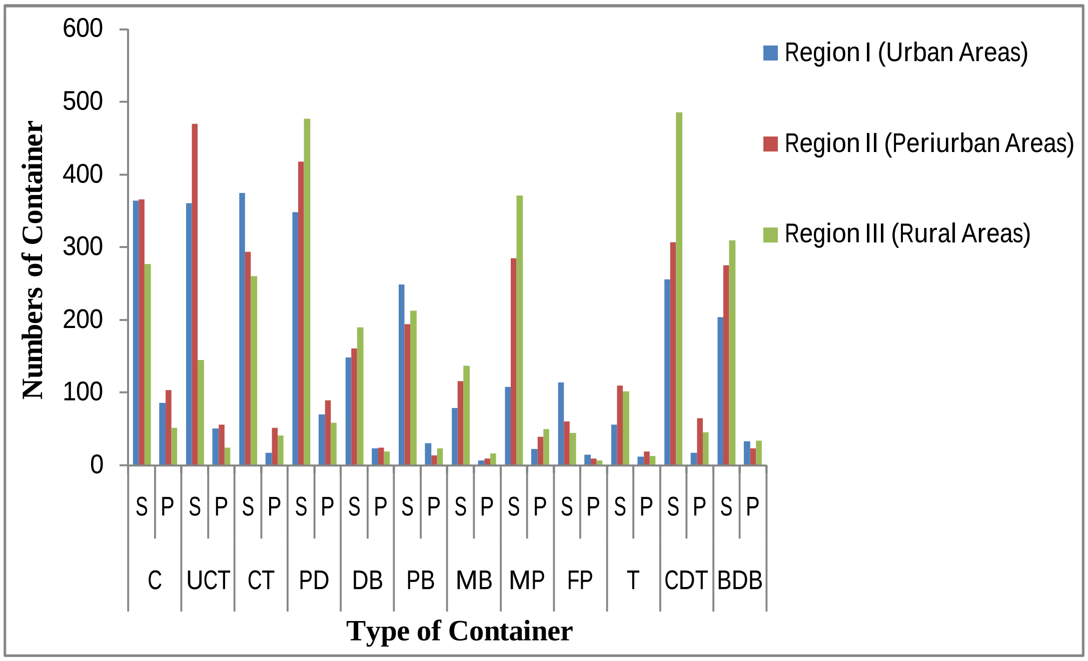
Table 1: Percentage positivity showing positive mosquito (larvae and pupae) breeding among different types of containers at Region-I (Urban areas), Region-II (Periurban areas) and Region-III (Rural areas) of Udaipur district of South Rajasthan during 2015 to 2018

Region (Areas)/ Containers type	C	UCT	CT	PD	DB	PB	MB	MP	FP	T	CDT	BDB	Total
Region-I (Urban Areas)	23.62%	14.12%	4.80%	20.11%	16.1%	12.44%	8.86%	21.29%	13.15%	21.42%	7.03%	16.17%	**14.57%**
Region-II (Periurban Areas)	28.41%	11.91%	17.68%	21.53%	15.52%	7.21%	8.62%	14.03%	16.39%	17.27%	21.17%	8.72%	**16.65%**
Region-III (Rural Areas)	18.77%	17.24%	15.74%	12.36%	10.00%	11.26%	12.40%	13.47%	15.55%	12.74%	9.46%	10.96%	**12.84%**
Total	**24.03%**	**13.52%**	**11.94%**	**17.61%**	**13.60%**	**10.51%**	**10.24%**	**14.79%**	**14.54%**	**16.41%**	**12.29%**	**11.53%**	**14.70%**

***C- Coolers, UCT- Underground Cemented Tanks, CT- Cemented Tanks, PD- Plastic Drums, DB- Discarded Buckets, PB- Plastic Bowls, MB- Metallic Bowls, MP- Mud Pots, FP- Flower Pots, T- Tires, CDT- Cattle Drinking Tanks, BDB- Bird Drinking Bowls**

Table 2: Entomological Indices of Region-I (Urban areas), Region-II (Periurban areas) and Region-III (Rural areas) of Udaipur district of South Rajasthan during 2015 to 2018

Region (Areas)	House Index (HI)	Container Index (CI)	Breteau Index (BI)	Pupae Index (PI)
Region-I (Urban areas)	11.76	14.57	31.93	33.74
Region-II (Periurban areas)	12.67	16.65	41.89	32.42
Region-III (Rural areas)	10.20	12.84	31.85	45.02



*C- Coolers, UCT- Underground Cemented Tanks, CT- Cemented Tanks, PD- Plastic Drums, DB- Discarded Buckets, PB- Plastic Bowls, MB- Metallic Bowls, MP- Mud Pots, FP- Flower Pots, T- Tires, CDT- Cattle Drinking Tanks, BDB- Bird Drinking Bowls

Graph 1: Number of Containers Searched and Found Positive for *Aedes aegypti* (L.) Breeding in Udaipur district of South Rajasthan

DISCUSSION

The present study revealed that the common breeding habitats for *Aedes aegypti* (L.) in the study area were Coolers, Underground Cemented Tanks, Cemented Tanks, Plastic Drums, Discarded Buckets, Plastic Bowls, Metallic Bowls, Mud Pots, Flower Pots, Tires, Cattle Drinking Tanks and Bird Drinking Bowls. Out of them Coolers, Plastic drums, Tires, Flower Pots, Mud Pots and Discarded Buckets were most favourable. The majorities of the residents in Udaipur district of South Rajasthan store tap and rain water in containers for domestic use. Storing rain and tap water is common practice due to irregular supply and preference of rain water for laundry purpose. Similarly Getachew et al., (2015) reported that tires (33.33 percent), barrels (16.04 percent), plastic drums (24.19 percent) and Jericans (19.01 percent) were most favourable containers for *Aedes* mosquitoes breeding in Dire Dawa, East Ethopia as compared to other searched containers in the entomological surveillance from May-June to September-October 2014 because of common practice due to irregular supply to store tap and rain water in containers for daily use.

The Entomological surveys of *Aedes* breeding of three islands i.e., Kadmat, Amini and Kavaratti in the Union Territory of Lakshwadeep revealed the maximum breeding of *Aedes albopictus* (Skuse) was found in coconut shells (57 percent), metal containers (9 percent), tyres (9 percent) and plastic containers (8 percent) (Sharma et al., 2008).

A study in Tirunelveli district, India, indicated that, due to poor rainfall and scarcity of water supply, the population stored water in various containers for long duration and these containers constituted the main mosquito breeding sources (Bhat and Krishnamoorthy, 2014).

Kumar et al., (2014) reported that among different inspected containers, fire extinguisher bucket (23%), coolers, earthen pots, disposable plastic cups and glass showed maximum potential for *Aedes* mosquitoes breeding during December 2010 in residential and operational areas of Mumbai Port Trust (MPT).

Our study also depicted that out of total surveyed houses (3645) for the presence of artificial breeding containers for *Aedes aegypti* (L.) mosquitoes for the presence of artificial breeding containers for *Aedes aegypti* (L.) mosquitoes. Maximum house infestation and container infectivity was detected in Region-II (Periurban areas) followed by Region-I (Urban areas) and Region-III (Rural areas). Similarly Yadav, (2017) during her studies in Rajasthan observed that periurban people store rainy water for drinking and also for other purposes due to scarcity of drinking water. So to get water without difficulty they have developed a practice to collect drinking water in the pots, underground cemented takas and underground takas which are good places for the mosquitoes to breed, while in urban areas water storage often occurs in the piped water systems because of intermittent water supply and due to the necessity of collecting supplementary rainwater, they don't collect water in domestic containers.

Wu et al., (2013) conducted a study by adult's survey with the sticky plastic in the High Dengue-Risk Areas (metropolitan and rural areas) of Taiwan and reported that the mosquito species captured was *Aedes aegypti* (L.) (2.8 percent and 1.8 percent in the metropolitan and rural areas, respectively), *Aedes albopictus* (0.5 and 0.6 percent in the metropolitan and rural areas, respectively), unidentified *Aedes* (1.8 and 1.3 percent in the metropolitan and rural areas, respectively), *Armigeres subalbatus* (0.1 percent for both areas) and *Culex quinquefasciatus* Say (66.5 percent and 24.6 percent in the metropolitan and rural areas, respectively), followed by Other mosquitoes collected were *Anopheles sinensis* Wiedemann, *Culex fuscanus* Wiedemann and *Culex sitiens* Wiedemann.

Tobias et al., (2016) reported that in urban environment *Aedes albopictus* (Skuse) egg density was 2.26 times higher than on intervention area, on the Italian side of the border, as compared to intervention area in Ticino. Researchers also found that ratio in egg densities between urban and sylvatic environment was twice as high in the non-interventionism area and *Aedes albopictus* (Skuse) egg densities in the non-interventionism area on the Italian region of the Swiss-Italian border were more than twice compared to the intervention area in Ticino.

According to World Health Organization, (2003; 2011) a locality with HI>10%, CI>10%, BI>50 & PI=1, considered as high risk of transmission of dengue whereas a locality with HI<1%, CI<1%, BI<3-5 & PI<1, considered as low risk of transmission. An HI >5% & BI >20 for any locality is an indication that the locality is dengue sensitive and therefore adequate preventive measures should be taken. The study revealed that important indices in all areas were above (HI>10.20 percent, CI>12.84 percent, BI>31.85 & PI>32.42), hence all study areas were at high risk of dengue disease transmission. Region-II (Periurban areas) was more susceptible for disease transmission than Urban and Rural areas. Similarly Kumar et al., (2014) concluded that all the entomological indices i.e. House Index (HI), Container Index (CI), Breteau Index (BI) and Pupae Index (PI) were above the critical level, prescribed for sea ports by (International Health Regulations Act, 2005) in their study that was undertaken during December 2010 to estimate the entomo-epidemiological threat of *Aedes* mosquito borne diseases (VBD) in operational and residential areas of Mumbai Port Trust (MPT) areas to minimize potential worldwide health risks and avert introduction of new vector borne diseases in India.

According to Bharathi et al., (2015) all blocks in three districts i.e., Dindigul HUD, Madurai and Theni of the Western Ghats region, Tamil Nadu, India were above emergency index during the fever outbreaks.

Similarly Sharma et al., (2005) reported that all indices i.e. House Index, Container Index and Breteau Index were significantly high during postmonsoon season during their study on *Aedes aegypti* undertaken in different areas of Delhi, during 2000.

All indices were at critical levels such as house index, container index, pupal index and Breteau index were 58.62 percent, 12.44 percent, 141.38 and 64.66, respectively in their entomological door-to door survey for dengue vectors in and around different localities in Kabir Nagar, Alwar, Rajasthan in March 2016 (Kumari et al., 2016).

In the surveillance study at different airports- Santa Cruz of Bombay, Dum Dum of Calcutta and Palam of Delhi. Container Index (CI) was observed as ranged from 1.6% to 86.7% at the Delhi Airport, while at Vizag, it was between 5.7% and 11.2% and at Cochin, 23.4% & 30.7%. Highest Breteau Index (185.7) was reported at old Chennai airport as 185.7, whereas it was ranged from 1.8% to 33.3% at Delhi (Sharma et al., 2020).

CONCLUSION

In the study area, the community store water in different domestic containers for long period of time for the daily use. In calculation to household containers, different discarded containers namely as discarded plastic bowls, discarded buckets and tires hold rain water for long period time. This enables *Aedes aegypti* (L.) to breed in these containers. As our present study showed, mainly of the containers were infested with *Aedes aegypti* (L.) mosquitoes which may serve as vector of dengue disease.

From this investigation, it is clear that there are many chances of dengue disease transmission in the sampling areas. However, to conclude whether this mosquito is transmitting ailment or not by looking for the virus in the mosquitoes needs additional investigation. There has to be a viral separation through collecting the adult females to look if they harbor the dengue disease pathogen. It also requires awareness creation of the people not to be affected by the disease in case epidemic may occur. Since this study was only in Udaipur district of south Rajasthan, it should also be in the whole south Rajasthan to identify the foci of the disease. In containers containing only tap water, *Aedes aegypti* (L.) mosquito larvae were not abundant and were found greatly in tap water mixed with rain water. This showed that the requirement to study water chemistry to know the motive behind the fact.

Acknowledgment

The authors would like to thank Professor and Head, Department of Zoology, University College of Science, Mohanlal Sukhadia University, Udaipur, Rajasthan for the laboratory facilities provided for the present investigation. All the authors also would like to express their sincere thanks to Dr. Rajpal Singh Yadav (Chair, Joint Action Group, Vector Control Response, WHO) Geneva, Switzerland and Dr. Roop Kumari (NPO, Malaria & VBD, WHO Country Office) New Delhi for providing instruments and equipments from WHO, which were very useful in completion of the study. We acknowledge the Office of the Chief District Medical Officer, Udaipur. The authors are extremely grateful to the people of Udaipur, district of South Rajasthan without whose support the study would not have been possible.

Conflict of Interests

Authors do not have any clash of interests.

REFERENCES

1. Bharathi, N., Ramakritinan, C.M. and Kolandaswamy, K. (2015). Geographical information system based study on Dengue and Chikungunya at Western Ghats districts, Tamil Nadu, India. *I.J.M.R.,* 2(3), 30-38.
2. Bhat, M.A. and Krishnamoorthy, K. (2014). Entomological investigation and distribution of *Aedes* mosquitoes in Tirunelveli, Tamil Nadu, India. *International Journal of Current Microbiology Application Sciences,* 10(3), 253-260.

3. Bhatt, S., Gething, P.W. and Brady, O.J. (2013). The global distribution and burden of dengue. *Nature,* 496, 504-507.
4. Favaro, E.A., Mondini, M.R. Dibo, A.A.C., Barbosa, A.E., Eiras, F.C. and Neto. (2008). Assessment of entomological indicators of *Aedes aegypti* (L.) from adult and egg collections in Sao Paulo, Brazil. *J. Vec. Ecol.,* 33, 8-16.
5. Focks, D.A. (2003). A Review of Entomological Sampling Methods and Indicators for Dengue Vectors, World Health Organization, Geneva, Switzerland.
6. Getachew, D., Tekie, H., Gebre- Michael, T., Balkew, M. and Mesfin, A. (2015). Breeding Sites of *Aedes aegypti*: Potential Dengue Vector in Dire Dawa, East Ethopia. Interdiscip. *Perspect Infect. Dis.,* 1-8.
7. Grodner, M.L. (1997) http://aapse.ext.vt.edu/archives/97AAP CO_report.
8. Guillena, J.B., Opena, E.L. and Baguio, M.L. (2010). Prevalence of dengue fever (DF) and dengue hemorrhagic fever (DHF): a description and forecasting, in Proceedings of the 11th National Convention on Statistics (NCS '10), pp.-16.
9. Kumar, K., Sharma, A.K., Sarkar, M., Chauhan, A. and Sharma, R. (2014). Surveillance of *Aedes aegypti* (L.) Mosquitoes in Mumbai International Seaport (India) to Monitor Potential Global Health Risks. Hindawi Publishing Corporation. *Journal of Insects*, 1-5.
10. Kumari, R., Patel, S., Kanhekar, L.J., Sharma, S.N., Chharang, N., Visth, B., Kaur, H., Sharma, R., Singh, P. and Venkatesh, S. (2016). Entomological Surveillance and Warning for Dengue Outbreaks in Alwar City, Rajasthan, India. *J. Commun. Dis.,* 48(4), 29-35.
11. Morrison, A.C., Zielinski–Gutierrez, E., Scott, T.W. and Rosenberg, R. (2008). DeÞning challenges and proposing solutions for control of the virus vector *Aedes aegypti*. *PLoS Med.,* 5, 68.
12. National Vector Borne Disease Control Programme (2020). Factsheet on the National Vector Born Disease Control Programme Report.
13. Prasad, A. and Kumar, A. (2020). Susceptibility status of dengue vector *Aedes aegypti* (L.) against various larvicides and insecticides in Udaipur district of Southern Rajasthan, India. *International Journal of Entomology Research,* 5(1), 74-77.
14. Ranson, H., Burhani, J., Lumjuan, N. and Black, W.C. (2010). Insecticide resistance in dengue vectors. *TropI KAnet Journal*, 1(1).
15. Rathore, M., Kashyap, A. and Kapoor, P. (2018). Journey of dengue in Rajasthan in the last 15 years (2001–2015) with special reference to 2015. *Indian Journal of Health Sciences and Biomedical Research KLEU,* 3-8.
16. Russell, R.C., Webb, C.E. and Davies, N. (2005). *Aedes aegypti* (L.) and *Aedes polynesiensis* marks (Diptera: Culicidae) in Moorea, French Polynesia: a study of adult population structures and pathogen (*Wuchereria bancrofti* and *Dirofilariaimmitis*) infection rates to indicate regional and seasonal epidemiological risk for dengue and filariasis. *Journal of Medical Entomology,* 42(6), 1045-1056.
17. Scholte, E.J., Knols, B.G.J., Samson, R.A. and Takken, W. (2006). Infection of the malaria mosquito Anopheles gambiae with the entomopathogenic fungus Metarhizium anisopliae reduces blood feeding and fecundity. *J. Invertebr. Pathol.,* 91, 43-49.
18. Sharma, R.S., Gupta, S.K. and Vikram, K. (2020). Surveillance of *Aedes aegypti* (L.) at different airport/seaports in India. *WHO Dengue Bulletin*, 41, 96-103.
19. Sharma, R.S., Kaul, S.M. and Sokay, J. (2005). Seasonal fluctuations of dengue fever vector, *Aedes aegypti* (Diptera: Culicidae) in Delhi, India. *Southeast Asian J. Trop. Med Public Health,* 36(1), 186-90.
20. Sharma, R.S., Showkath Ali, M.K. and Dhillon, G.P.S. (2008). Epidemiological and entomological aspects of an outbreak of chikungunya in Lakshadweep Islands, India, during 2007. *WHO Dengue Bulletin*, 32, 178-185.

21. Tobias, T., Suter, Flacio E., Fariña, B.F., Engeler, L., Tonolla, M., Regis, L.N., Maria, A.V., Santos, D.M. and Müller, P. (2016). Surveillance and Control of *Aedes albopictus* in the Swiss-Italian Border Region: Differences in Egg Densities between Intervention and Non-intervention Areas. *PLOS Neglected Tropical Diseases.,* 1-14

22. Tun-Lin, W., Kay, B.H., Barnes, A. and Forsyth, S. (1996). Critical examination of *Aedes aegypti* indices: correlations with abundance. *The American Journal of Tropical Medicine and Hygiene,* 54(5), 543-547.

23. Webb, C.E. (2008). Mosquito ecology: field sampling methods. *Australian Journal of Entomology,* 47(4), 382-383.

24. World Health Organization (2017). Factsheet on the World Malaria Report.

25. World Health Organization, (2011). Current states of Malaria.

26. World Health Organization. (2003). Guidelines for dengue surveillance and mosquito control. Second edition. Manila. 1-115.

27. World Health Organization. (2011). Comprehensive Guidelines for Prevention and Control of Dengue and Dengue Haemorrhagic Fever. Revised and expanded edition. *SEARO Technical Publication Series* 60, 1-212.

28. Wu, H.H., Wang, C.Y., Teng, H.J., Lin, C., Lu, L.C., Jian, S.W., Chang, N.T., Wen, T.H., Wu, J.W., Liu, D.P., Lin, L.J., Norris, D.E. and Wu, H.S. (2013). A Dengue Vector Surveillance by Human Population-Stratified Ovitrap Survey for *Aedes* (Diptera: Culicidae) Adult and Egg Collections in High Dengue-Risk Areas of Taiwan*. J. Med. Entomo*l, 50(2), 261-269.

29. Yadav, K. (2017). Dengue in Rajasthan. *International Journal of Scientific & Engineering Research,* 8(1), 411-418.

****