International Journal of Mosquito Research

ISSN: **2348-5906**
CODEN: **IJMRK2**
IJMR 2019; 7(4): 78-82

www.dipterajournal.com
Received: 04-05-2020
Accepted: 06-06-2020

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Seasonal variation and breeding preference of *Aedes albopictus* in one of the coastal districts of Kerala

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Abstract
Entomological surveillance was carried out in randomly selected urban and rural areas of Alappuzha district to find out the diversity of breeding habitats, larval indices, and preferred breeding habitats of *Aedes* mosquitoes. All the three larval indices such as House index (HI), Container index (CI) and Breteau index (BI) were significantly high in post monsoon than in pre monsoon both in urban and rural areas of Alappuzha district. In urban area, the most preferred breeding sources of *Aedes* mosquitoes were used tires (4.84) followed by plastic (1.24). A similar observation was found in rural area, in which the breeding preference ratio was more in tires (8.79) followed by plastic (1.58). In the present study, the factors favoring the breeding of vector mosquitoes especially *Aedes* species, reasons for the prevalence of this mosquito in the premises and most appropriate vector control strategy are discussed in detail.

Keywords: Seasonal variation, breeding preference ratio, *Aedes*-borne diseases

Introduction
Vector-borne diseases are reported in over 100 countries and 60% of the global population is under the threat of infection; more than 500 million cases reported each year [1]. Mosquito vectored viral diseases include Dengue, Chikungunya, Zika, Yellow fever, West Nile and Japanese encephalitis. The virus causing DF/DHF is present almost throughout India and has emerged as a major public health concern.

Globally, 2.5 billion people live in areas where dengue viruses can be spread and the prevalence of dengue has increased dramatically in recent decades. As per WHO estimates 50 to100 million dengue cases worldwide every year [2]. Before 1970, only nine countries had experienced severe DF/DHF epidemics. At present Dengue fever is endemic in more than 100 countries including Africa, Americas, Eastern Mediterranean, South-East-Asia and Western Pacific regions [2].

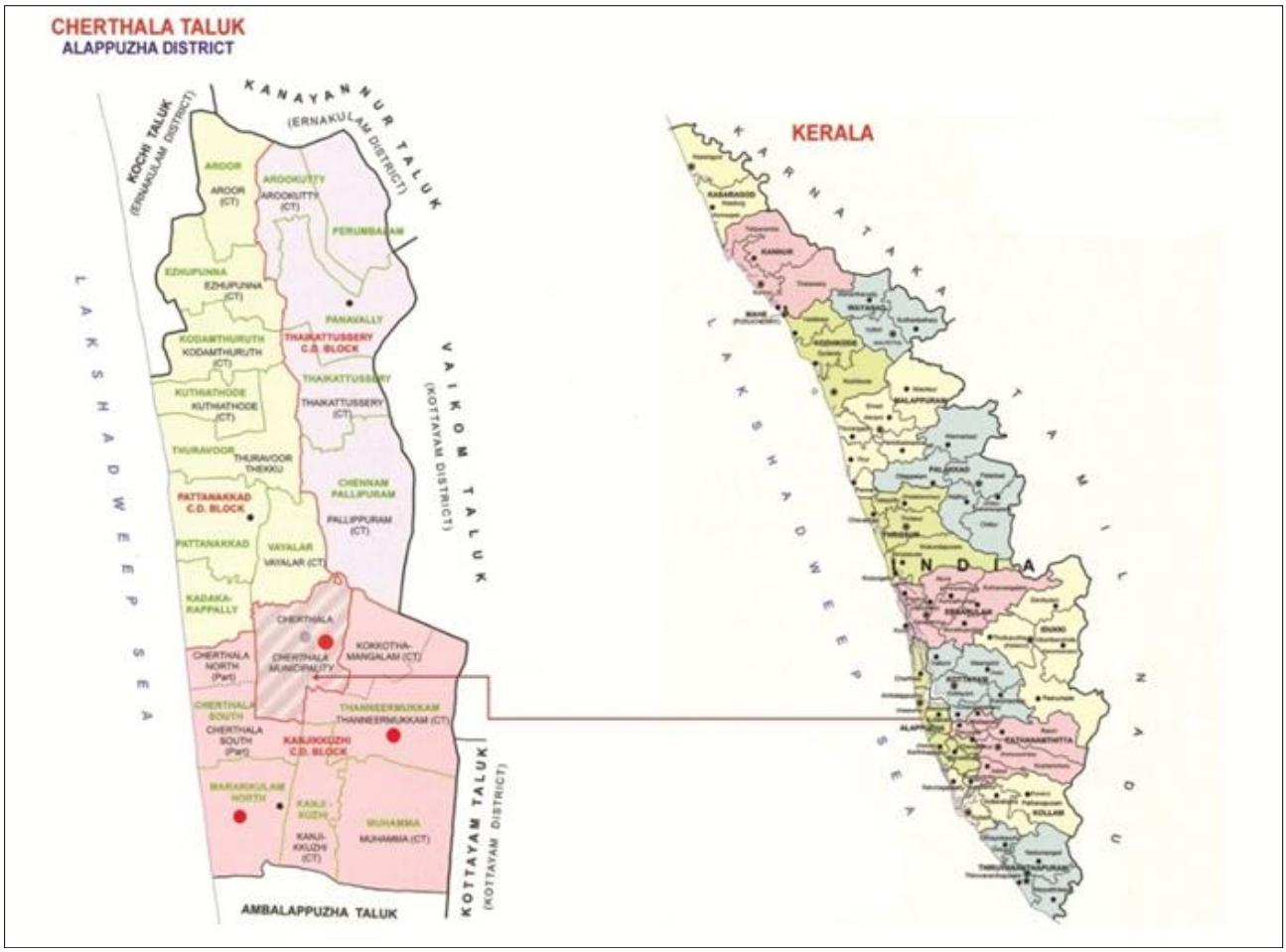
Dengue infection is caused by any one of four types of distinct but closely related viruses, namely, DEN1, DEN 2, DEN 3 and DEN 4 of the genus *Flavivirus*. Several species of *Aedes* mosquitoes are associated with dengue/dengue hemorrhagic fever and chikungunya, but *Ae. aegypti* and *Ae. albopictus* are the two most common vectors in human beings[3]. *Ae. aegypti* breeds in man-made containers, whereas *Ae. albopictus* is mainly a forest edge species and adapted to rural, urban and suburban habitats breeding in natural sources such as tree holes, bamboo stumps and leaf axils in the forest and in man-made containers in suburban and urban areas [4]. It has been listed as one of the world's worst invasive species by the World Conservation Union having already invaded many countries around the world [5].

Kerala is facing the outbreaks of DF/DHF since 1997 and chikungunya from 2006. A total of 36,058 dengue fever cases and 125 deaths (0.35%) were reported from Kerala during 2011 - 2017. The suspected and confirmed chikungunya cases reported in the district during the same period are 1,165 and 984 respectively [6]. Dengue fever cases have been reported from Alappuzha since 2003. A total of 2,711 DF cases and 11 deaths (0.40%) were reported in Alappuzha district from 2011-2017. *Ae. albopictus* is the most common vector species found and has been incriminated as the sole vector of DF/DHF so far in Kerala [7]. The knowledge regarding the prevalence, breeding habitats and seasonal variation of *Aedes* mosquitoes in Kerala, especially in the coastal districts, is meager. Hence, a study has been carried out on the bio-ecology of *Aedes* mosquitoes in rural and urban areas of Alappuzha district, one of the coastal districts of Kerala.

Materials and methods

Study area

The present study was done in randomly selected urban (Cherthala Municipal area) and rural (Thannermukkam and Mararikkulam North Panchayaths) areas of Alappuzha district (Map 1). Alappuzha is an important tourist destination in southern Kerala with Arabian Sea on the west, a vast network of backwaters, lagoons and fresh water rivers criss-crossing the land. Alappuzha has a high population density (1492/sq.km.). The total geographical area is 1414 sq.km. The district lies between $9^0$5' north latitude, $76^0$17' and $76^0$44'east longitudes. The district is mostly of water logged plain, having no highlands and forests. The district has a coast line of 82 kms.



Map 1: Alappuzha district (Cherthala taluk) Showing studay area

The area receives plentiful rain (average 3000 mm a year) each year. The temperature normally varies from 28^0C to 32^0C.

Entomological surveillance

Vector surveillance was carried out in randomly selected urban and rural areas of Alappuzha district during pre monsoon and post monsoon seasons in 2018. The houses and their surroundings were searched for mosquito breeding. All the water holding containers/habitats were examined for larval breeding. The immature stages of mosquitoes from each container/ breeding source were collected separately. The larvae were identified instar-wise and fifty percent of fourth instar larvae were identified microscopically and the remaining larvae and pupae were identified after adult emergence following standard guidelines [8]. *Aedes* larval indices- House index (HI), Container index (CI), Breteau index (BI), the preferred breeding habitats and seasonal variation of vector breeding were analyzed.

Results

A total of 200 house premises were searched for *Aedes* breeding in Cherthala Municipal area (urban) during the pre monsoon period. *Aedes* breeding was noted in 11 premises (HI - 5.5%). Of the total 485 water holding containers/ sources searched in the urban area, 12 containers were found positive for *Aedes* larvae (CI- 2.47%). In order to find out a relation between positive containers and number of houses examined for larval presence, the Breteau index (BI) was calculated and was found to be 6.0.

An attempt was made to compare the *Aedes* larval indices in pre monsoon and post monsoon in urban area. Entomological survey was carried out in urban area during the post monsoon. A total of 200 houses, as has been done during pre monsoon, were searched for vector breeding in the same urban area. *Aedes* breeding was noted in 23 premises (HI- 11.5%). Of the total 443 water holding containers/sources searched, 26 containers were found positive for *Aedes* larvae (CI-5.86%). The Breteau index was found to be 13.0. The *Aedes* larval indices in the urban area during post monsoon were significantly higher than that in pre monsoon (Fig 1).

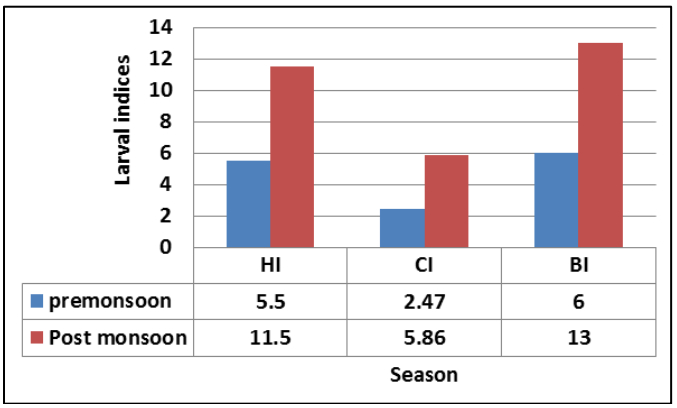


Fig 1: *Aedes* Larval indices in Premonsoon and Post monsoon (Urban area)

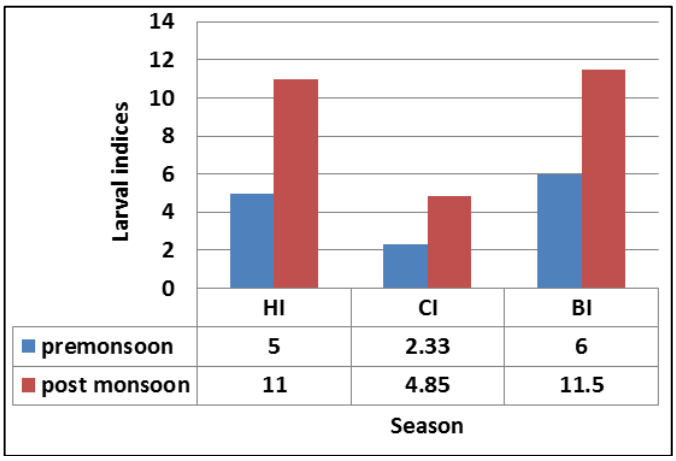


Fig 2: *Aedes* Larval indices in premonsoon and post monsoon (Rural Area)

In order to find out any difference in selecting the breeding habitats of *Aedes* mosquitoes in urban and rural area, 200 house premises were searched in the rural area during pre monsoon. *Aedes* breeding was noted in 10 premises (HI-5.0%). Of the total 539 water holding containers/sources searched, 12 containers were found positive for *Aedes* larvae (CI-2.47%). The Breteau index (BI) was calculated to be 6.0. In order to compare the *Aedes* larval indices in both the seasons in the rural area, the survey was done in post monsoon season also. The House index, Container index and Breteau index in the post monsoon survey were 11.0%, 4.85% and 11.5 respectively (Fig 2).

All the larval indices showed a marked increase during post monsoon in the rural area (Fig 2). The study indicated that irrespective of urban and rural differentiation, all the three larval indices were high during post monsoon.

The position and nature of water holding containers seen scattered in the peridomestic environment may influence site selection of *Aedes* mosquitoes for egg laying. An analysis has been done to find out the most preferred breeding sources of *Aedes* mosquitoes. The Breeding Preference Ratio (BPR) was found to be more in tires followed by plastics in both urban and rural areas of Alappuzha district (Fig 3 & Table 1).

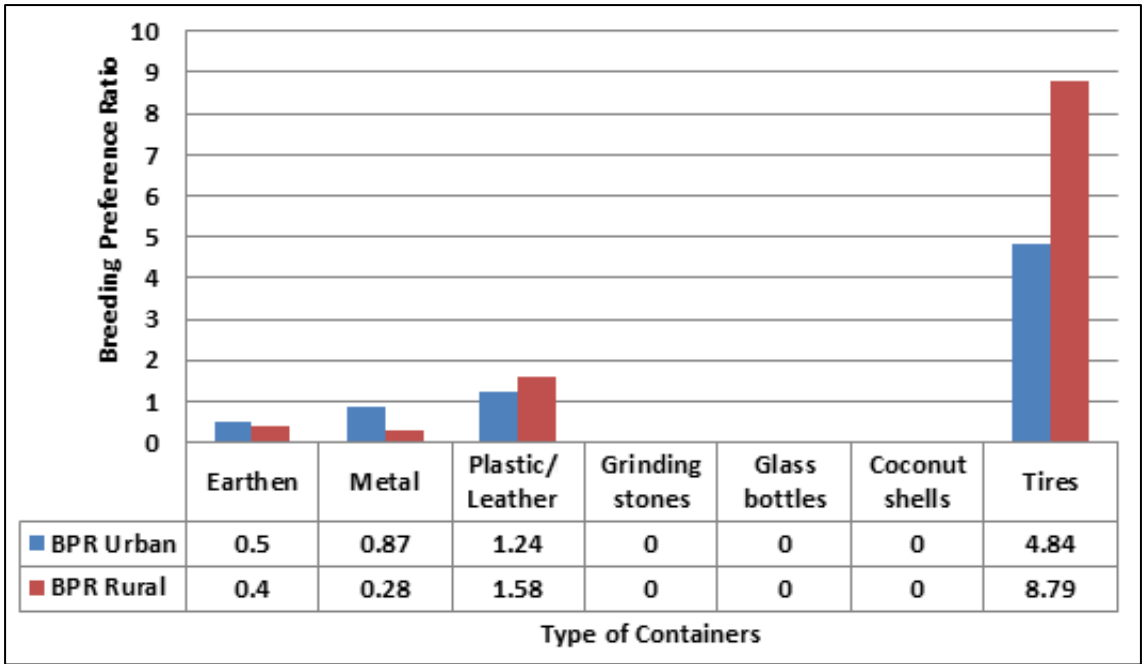


Fig 3: Breeding Preference Ratio in urban and rural areas of Alappuzha district

Table1: Breeding habitats of *Aedes* mosquitoes in Urban and Rural areas of Alappuzha District

S. No.	Type of containers	URBAN			RURAL		
		E	P	BPR	E	P	BPR
1	Earthen	147 (15.84)	03 (7.89)	0.50	199 (21.56)	03 (8.57)	0.40
2	Metal	252 (27.16)	09 (23.68)	0.87	284 (30.77)	03 (8.57)	0.28
3	Plastic/Leather	413 (44.50)	21 (55.26)	1.24	417 (45.18)	25 (71.43)	1.58
4	Grinding stones	36 (3.88)	0	0	26 (2.82)	0	0
5	Glass bottles	46 (4.96)	0	0	57 (6.18)	0	0
6	Coconut shells	8 (0.86)	0	0	18 (1.95)	0	0
7	Tires	26 (2.80)	05 (13.56)	4.84	12 (1.30)	04 (11.43)	8.79

E-examined, P-Positive, figures in parentheses indicate percentage value

Discussion

Among the blood feeding insects, mosquitoes form an important group and have been tormentor of human beings from the time immemorial and continue to challenge the ingenuity of man. The most important mosquito-borne viral diseases include Dengue, Chikungunya, Zika, Yellow fever (not reported from India so far), Japanese encephalitis, West Nile, etc.

Dengue is one of the most important tropical diseases claiming heavy morbidity and mortality. The disease is mainly transmitted by *Ae. aegypti*, the tiger mosquito and *Aedes albopictus*, the Asian tiger mosquito.

In Kerala, dengue fever occurred in Kottayam district in 1997 and by 2003 dengue was reported in all the fourteen districts of Kerala and since then this disease continues to be a great health issue in the state [3, 9].

The survey carried out by NCDC, Kerala branch (former NICD) during the last twenty five years showed *Ae. albopictus* is the most predominant species (more than 92%) among the *Aedes* species of mosquitoes in Kerala [10]. *Ae. albopictus* is mainly a container breeder. It breeds in natural and artificial habitats with equal ease. Human ecology plays a significant role in the creation of mosquitogenic environment and pave for dengue/chikungunya vector proliferation. In the present study, it has been found that *Ae. albopictus* was the species prevalent in both urban and rural areas of Alappuzha, one of the southern coastal districts of Kerala.

In Kerala, the South-West monsoon starts by the end of May or early June and fades out by September. The North-East monsoon commencing in October continues up to mid December. The summer starts towards the end of January and continue till the end of May. Kerala receives heavy rainfall during Southwest monsoon compared to Northeast monsoon. The average rainfall during Southwest monsoon and Northeast monsoon ranged 2250-2500 mm and 450-500 mm respectively. One of the characteristics of climate in Kerala is the onset of summer rains especially in the months of April and May, the concluding months of summer season and it is evident from the average rainfall data of Kerala. The monthly rainfall (mm) during the months of January, February and March are 14.6, 16.6, and 36.1 respectively. However the average rainfall, during the end months of the season i.e., on April and May, are 110.9 mm and 252.6 mm respectively.

Entomological study carried out by NCDC, Kozhikode (Kerala branch) throughout the state clearly indicated that all the three *Aedes* larval indices are high during the summer rainy days compared to heavy rainy days. In Kerala, normally heavy rain begins from mid June and continues up to mid August. During monsoon, due to inundation, most of the larval breeding sources in the peri-domestic environment especially in a low-lying area like Alappuzha district, are likely to be washed away and hence the larval density will be low when compared to summer rainy days or post monsoon period. In the present study comparison of *Aedes* larval indices was done on the basis of the work done during pre monsoon and post monsoon seasons in both urban and rural areas of Alappuzha district. It has been found that the larval indices such as House index, Container index and Breteau index were significantly high in post monsoon irrespective of urban and rural areas.

Ae.albopictus mosquitoes prefer to breed in containers filled with rain water seen scattered in the premises. This mosquito is obviously rain water dependent and its larval density slowly builds up in the summer rainy days. The combination of infrequent rainy and sunny days during the summer time increases the egg laying potential of *Ae. albopictus* to a great extent.

The *Aedes* survey carried out in Alappuzha district showed that most preferred breeding sites of *Ae. albopictus* mosquitoes were tires followed by plastic containers in both urban and rural areas. In an entomological surveillance carried out in Alappuzha district, it has been observed that the most preferred breeding sources based on breeding preference ratio was tires in both rural and urban areas [9]. It is possible because of rapid urbanization taking place in Kerala. In most of the districts of Kerala the demarcation between rural and urban is insignificant and this stands true for Alappuzha district too. Among the total households surveyed in urban area, 64% were having two/three wheeler vehicles, 51% were with four wheelers and 40% were having two/three & four wheelers. On the other hand in the rural area, 65% of the households were having two/three wheelers, 44% with four wheelers and 35.5% were having all the three types of vehicles. Usually, many households carelessly discard the used tires in the premises. *Aedes* mosquitoes especially *Ae. albopictus* has a predilection to lay eggs in the stagnated rain water in the tires. Our field experience clearly indicated that in a locality the number of tires may be less when compared to other types of containers/sources. However we could observe the breeding of *Aedes* larvae in almost all used tires even though the number of tires seen scattered in the premise is less. This is supportive of many earlier research findings that automobile tires holding rain water is a major breeding site of *Aedes* mosquitoes [9, 11, 12, 13].

In the present study, it has been found that in addition to used automobile tires, water holding plastic containers are also important breeding sites of *Aedes* mosquitoes. Having increasingly prone to the consumerist culture, the people have fallen victim to the thrown away habit. House premises,

market places, public places all are laden with scattered heaps of trash mostly of non-degradable materials such as plastic, wrappers and carriers. These are capable of retaining water for many weeks especially during rainy season and pave for profuse breeding of *Aedes* mosquitoes [14].

Aedes-borne diseases such as dengue, chikungunya, zika, etc. are in many ways the prototype of 'Man-made diseases'. *Aedes* mosquitoes generally breed in containers/sources seen in the vicinity of human shelters. There is no need of any advanced technology for the control of these tiny insects. The main concept of *Aedes* control is simply denial of the conveniences for their egg laying. The flight range of these mosquitoes is very short and being highly anthropophagic and of day biting nature, they always swarm around the human settlements. Kerala being highly literate state, even the children knew the whereabouts of mosquitoes through various print, electronic and social media. However, rather than awareness, lack of a conscious preparedness and a willful resolve deter the people in cleaning the environment regularly and removing the unwanted and thrown away broken containers or other things that are possible sources acting as potential breeding sites of the vector mosquitoes. Unfortunately, in many occasions, public health preventive programs may compromise to be simple 'observation days'. However, there is no 'short cut' to replace the source reduction strategy. Instead, searching for newer vector control methods seems to be wasteful of time and resource and short of insight. Mosquito control programs have to be more community oriented and participatory so as to ensure sustainability, environmentally safe and economically affordable.

Conclusion

Vector surveillance was carried out in randomly selected urban and rural areas of Alappuzha district during pre monsoon and post monsoon seasons in 2018. It has been found that *Ae.albopictus* was the species seen in the study area. In the present study we couldn't detect *Ae. aegypti* during the household survey, which indicate the possible role of *Ae.albopictus* in transmitting Dengue fever and chikungunya.

Acknowledgements

The authors are grateful to the Director, NCDC, Delhi for providing opportunity to undertake the survey in Alappuzha district. Thanks to health inspectors of Cherthala Municipality, Thannermukkom and Mararikkulam PHCs for their help and cooperation for carrying out the vector surveillance in the target areas.

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