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Dengue vector abundance and diversity of breeding habitats in Puducherry, South India

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Abstract. Puducherry had reported regular dengue outbreaks since 2003 with many-fold increase in number of cases every year. This study was done to assess the intensity of dengue vector breeding and diversity of breeding habitats. *Aedes* surveys were conducted in 8 Primary Health Centres (PHCs) representing both rural and urban areas of Puducherry district throughout the year 2012. Containers inside and outside randomly (simple) selected houses and vacant sites around houses were examined for presence of *Aedes* mosquitoes. The containers containing water with immature larvae were designated as positive containers (PC), while the containers holding only water were designated as wet containers and all the larvae/pupae from the positive containers were collected and entomological indices were determined using standard WHO methods. The vectors, *Aedes aegypti* and *Ae. albopictus* were encountered in the survey, with *Ae. aegypti* present in high numbers in urban as well as rural areas. The plastic containers were found as the most productive indoor breeding habitat as the 27.2% of the total pupae collected was contributed by plastic containers followed by flower vase (22.8%) and grinding stone (17.6%). Larval indices were found to vary throughout the year and highest indices were recorded during the months of October and November indicating the potential risk of dengue fever during this period.

INTRODUCTION

The incidence of dengue has grown dramatically around the world in recent decades. Dengue, places 2.5 billion people in more than 100 countries at risk causing an estimated 50 to 100 million cases of dengue infections worldwide annually and thousands of deaths (W.H.O, 1999; Gubler, 2005). In India, the first outbreak of dengue fever was recorded in 1812(Jatanasen & Thongcharoen, 1993). In spite of the preventive measures taken by the respective governments since then, recurrent outbreaks have been reported in most of the states of the country. Puducherry had reported first dengue outbreak in 2003 and since then regular outbreaks have been reported with major outbreaks in 2011(463 cases) and 2012(3506 cases) (NVBDCP). There is no specific treatment for dengue, however, with frequent and appropriate medical care; the lives of patients with the more serious dengue haemorrhagic fever (DHF) could be saved. The only way to prevent the transmission of dengue virus is to combat the vector, *Aedes* mosquito (WHO, 1999]. Vector surveillance is an important tool to generate entomological data needed for control strategies and to develop an early warning system (Pant & Self, 1993).Larval control (source reduction or suppression) has been identified as one of the most effective methods for the control of mosquito borne diseases (Singh *et. al.*, 2006). This control strategy has proved indispensable as the key to mosquito borne eradication efforts in most developed countries such as the United State of America and some countries in Europe such as Turkey (Kitron & Spielman, 1989; Mwangangi *et. al.*, 2009). Prior to launching the anti-mosquito larval measures, there is a need of determining the vector abundance and diversity of the breeding habitats available for the ovipositing mosquitoes in different localities. The incidence of dengue is largely dependent on vector populations and the frequency of contact between the vectors and susceptible human hosts, reflected by a positive correlation of *Aedes* abundance and prevalence with dengue (Tewari *et al.*, 2004; Mahadev *et al.*, 2004; Chadee, 2009). This supports the necessity of entomological surveillance to assess and predict the abundance of vectors and possibilities of occurrence of dengue (WHO-SEARO, 2006; Focks & Alexander, 2006). Conventionally, assessment and prediction of the vector population levels are made using the productive larval habitats and data on human demography as components of different indices recommended by the WHO (Focks & Alexander, 2006). The information provided by these indices is useful supplement for the management strategies against the dengue vectors, in different parts of the world (Focks & Alexander, 2006; Chadee, 2009). The present study was therefore conducted to determine the vector indices and container breeding preferences of mosquitoes by larval survey in the Puducherry. Such information can be used to design an effective vector control measures.

MATERIALS AND METHODS

Study area

Puducherry district lies between 11°46' & 12° 13' North and 79°36' & 79°53' East, with a population of 9, 46,600 covering an area of 293 sq. Km. Puducherry experiences hot and humid climate except during January & February months which are comparatively colder but the temperature never falls below 20°C. The temperature normally varies between 26°C and 38°C. The northeast monsoon sets in during the middle of October, and Puducherry gets the bulk of its annual rainfall during the period from October to December. Average annual rainfall is 1254 mm and relative humidity varies from 70 to 80% (Anonymous, 2012).

Mosquito immature surveys were conducted in 8 selected PHCs of Puducherry district throughout the year 2012. Every month, containers inside and outside

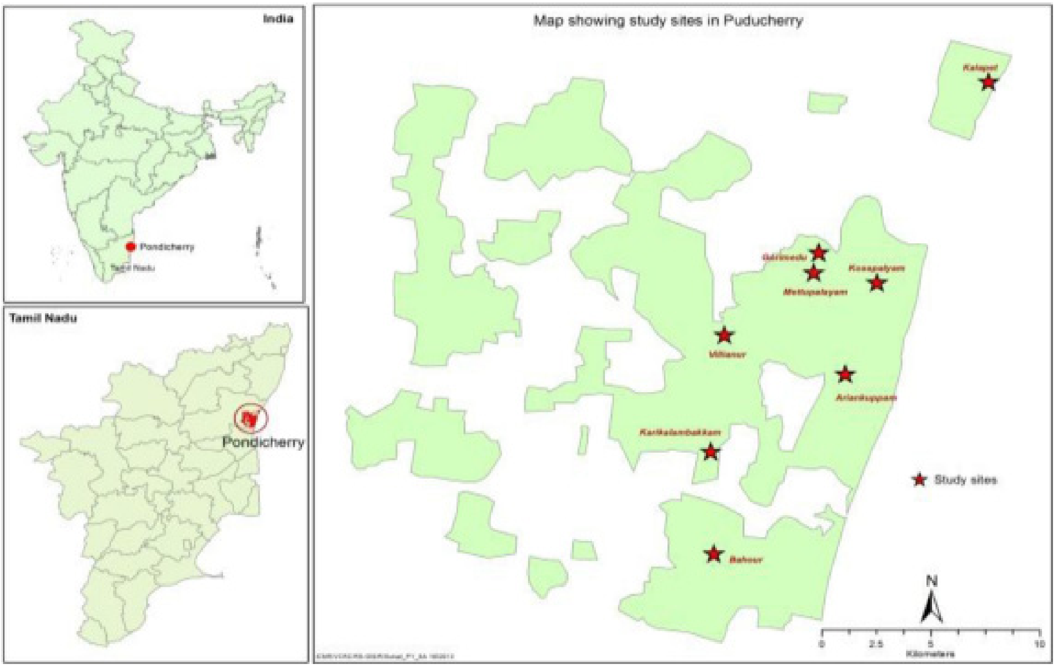

Figure 1. Map showing the study sites

randomly (simple) selected houses and vacant sites around houses were examined for the presence of *Aedes* mosquitoes. The containers holding water with immature were designated as positive containers (PC), while the containers holding only water were designated as wet containers and all the larvae/pupae from the positive containers were collected. Specimens of immature mosquitoes kept in plastic containers were labelled with date of collection, area code, house identification code, and container code before being transported to the laboratory. The larvae/ pupae collected from each locality were reared up to the emergence of adults and identified using standard keys (Tyagi *et al.*, 2012).

Entomological indices namely Breteau index (BI; The number of positive containers per 100 houses), House index (HI; The percentage of houses with positive containers) and Container index (CI; The percentage of containers with immature *Aedes*) were calculated following standard procedures (WHO-SEARO, 2011). As it has been reported that pupal indices are a better proxy indicator for adult vector abundance (Wai *et al.*, 2012), the pupal productivity surveys were carried out to identify the key breeding habitats. The pupal indices, pupae per person index (PPI: the ratio of pupae and persons living in each PHC) and pupae per container index (PCI: the ratio of pupae and containers surveyed in each PHC), were also determined. To identify the most productive container types, the percentage contribution of each breeding container to the total count of pupae was calculated. This was done by taking the total number of pupae found in a given category of container and dividing it by the total number of pupae in all containers in the area studied (Arredondo & Valdez, 2006).

RESULTS AND DISCUSSIONS

A total of 3698 houses from 8 PHCs were checked for *Aedes* larvae/pupae during the year-long surveillance. Immature *Aedes* were found in 513 houses and in 751 containers situated in and around the houses, which produced an overall 3070 *Ae. aegypti* and 612 *Ae. albopictus*. The immature indices of *Aedes* vectors in urban areas were relatively higher as compared to rural areas. Urban and rural areas showed closer HI compared to BI & CI, and both *Ae. aegypti* & *Ae. albopictus* were found in high numbers in urban PHCs as compared to the rural (Table 1).

While the container index (CI) between rural and urban area showed a significant difference (χ^2=7.40; P=0.007), the HI (χ^2=0.62; P=0.43) and BI (t=1.05; df =70; P=0.30) did not differ significantly. During

Table 1. Entomological indices in different study sites

	PHC	House index (HI)	Container index (CI)	Breteau index (BI)	No. of *Aedes aegypti* larvae	No. of *Aedes albopictus* larvae
Urban	Mettupalayam	16	17.8	20.4	358	75
	Kosapalayam	12.8	17.6	20.6	269	21
	Ariankuppam	13.4	17.4	23.2	608	135
	Gorimedu	16.4	16.2	21.5	437	86
	Total	14.6	17.2	21.4	1672	317
Rural	Kalapet	11.2	12.5	17.1	247	57
	Villianur	12.2	14.2	18.3	458	74
	Bahour	12.8	12.8	17.7	297	73
	Karikalampakkam	14.0	16.4	19.6	396	91
	Total	12.5	14.0	18.2	1398	295

entomological survey we identified uncovered water containers (including household water storage containers and other types of artificial containers) both indoors & outdoors as breeding habitats of *Aedes* vectors. The small plastic containers were the most productive indoor breeding habitat as the 27.2% of the total pupae collected was contributed by plastic containers followed by flower vase (22.8%) and grinding stone (17.6%). The discarded tyre (19.2%) were found as most productive outdoor breeding habitat followed by small plastic container (18.3%) & grinding stone (18.0 %) (Table 2).

Monthly larval indices were also determined and the highest larval indices were recorded during the months of October (HI-35.6, CI-17.9 & BI-49.8) and November (HI-35.7, CI-20.2 & BI-52.3). This sudden increase in the larval indices was due the highest rainfall recorded during the period, increasing the number of breeding habitats. The monthly HI (r=0.74, P=0.005) and BI (r=0.71, P=0.008) were found positively correlated to the monthly rainfall, while no significant relation was found between CI & rainfall (r=0.27; P=0.38) (Figure 2).

In addition, the vacant sites around houses were also surveyed during the monsoon season between September to December 2012 for the presence of *Aedes* breeding containers. Heaps of waste with diversity of breeding containers were found in vacant sites. Larval samples were collected from the positive containers, reared to adult stage in laboratory and identified species-wise using standard identification keys. A total of 240 vacant sites were surveyed and 180 vacant site were found positive containing 265 positive containers, producing 706 *Aedes aegypti* and 298 *Aedes albopictus* (Table 3).

The results of the present study showed the infestation characteristics of dengue vectors and indicated that the dengue vectors, *Ae. aegypti* and *Ae. albopictus* has spread all over the study area with moderate to high immature indices. Our study reflects that the immature indices can be used as an indicator of the abundance of the *Aedes* mosquitoes, serving as a supplement to assess the risk of

Table 2. Diversity and productivity of the containers surveyed

Location	Container type	No. of containers surveyed	No. of positive containers	No. of *Aedes* pupae collected	Pupae per container index (PCI)	Contribution to the total no. of pupae collected (%)
Indoor	Small plastic container	377	71	105	1.7	27.2
	Flower vase	421	69	88	1.3	22.8
	Grinding stone	156	31	68	2.2	17.6
	Earthen pot	224	33	46	1.4	11.9
	Plastic drum	117	28	31	0.9	8.0
	Iron drum	134	22	24	1.1	6.2
	Fridge tray	213	21	13	0.6	3.4
	Unused vessel	87	12	11	0.9	2.9
Outdoor	Discarded Tyre	287	73	127	1.7	19.2
	Small plastic container	444	82	121	1.3	18.3
	Grinding stone	231	50	119	2.4	18.0
	Flower vase	291	42	54	1.3	8.2
	Coconut shells	1131	57	52	0.9	7.9
	Earthen pot	183	30	48	1.6	7.3
	Iron drum	207	39	47	1.2	7.1
	Tea cups	319	32	39	1.2	5.9
	Plastic drum	106	23	25	0.9	3.8
	Unused vessel	101	17	21	1.2	3.2
	Glass bottle	103	6	9	1.5	1.4

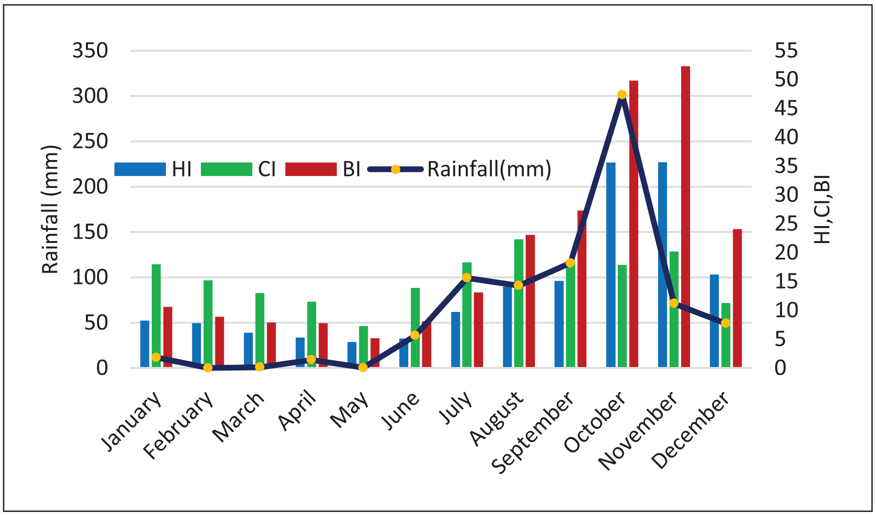

Figure 2. Correlation between monthly larval indices & rainfall - 2012

Table 3. Dengue vector density in vacant sites around houses

PHC	Vacant sites surveyed	Positive sites (%)	Positive containers	No. of *Aedes aegypti* larvae	No. of *Aedes albopictus* larvae
Mettupalayam	26	22 (84.6)	46	123	54
Ariankuppam	31	23 (74.2)	37	94	43
Kosapalayam	17	13 (76.5)	18	67	19
Gorimedu	22	16 (72.7)	21	61	26
Bahour	37	29 (78.4)	41	109	56
Kalapet	34	25 (73.5)	34	65	21
Villianur	34	24 (70.6)	29	86	38
Karikalampakkam	39	28 (71.8)	39	101	41
Total	240	180 (75)	265	706	298

dengue in Puducherry. In a previous study in Kolkata, India, plastic drums and small plastic containers were found as the key habitats of *Ae. aegypti* breeding and discarded plastic pots were identified as the most productive containers (Banerjee *et al.*, 2013). Similar observations were made from the present study with the plastic containers being most productive indoor breeding habitat & second most productive container after discarded tyre as far as outdoor breeding is considered. The individual and population level fitness of the principal vectors of dengue can be evaluated from the densities in the respective container habitats. Considering Puducherry and the type and amount of solid wastes generated, it is more probable that the plastic, glass and rubber waste materials generated from household or otherwise augment the availability of possible larval habitats and their utility as ovipositor sites by *Aedes* mosquitoes. This has been confirmed as the present study reported high population density of *Aedes* vectors in vacant sites that indicates lack of proper waste management facilities in the district that is a matter of prime concern. There is, therefore, a need for public health education campaigns that focus on the dangers inherent in the indiscriminate disposal of containers and storage of water inside the house as this serves as a potential breeding sites for the mosquito vectors. There is also need for further studies to evaluate the knowledge and awareness of the residents on dengue vector breeding and possible barriers that could be encountered during public health education on vector borne diseases at the study area. The abundance of dengue vector species in this area predisposes the inhabitants of this area to the risk dengue fever. This calls for an accelerated campaign of mosquito control in this area especially during the Rainy season encompassing the targeted vector management approaches.

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