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Research Article

STUDIES ON THE MOSQUITO DIVERSITY WITH SPECIAL REFERENCE TO DENGUE VECTORS IN VELLORE DISTRICT, TAMIL NADU, INDIA

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ABSTRACT

Dengue is currently spreading rapidly on a global scale. With rapid and unplanned urbanization dengue is now a more serious problem than before. To obtain a complete and systematic data about breeding habitats and density of vector immatures (larvae and pupae) and adults in a dengue and filarial endemic area. All the possible permanent and temporary water bodies were surveyed for the study of distribution, abundance and diversity of mosquitoes in Vellore district between July, 2015-December, 2015. Ten (10) locations were sampled using sweep nets, aspirators, dippers, and pipettes. The collected mosquitoes were preserved in 70% ethanol and identified to species level using morphological keys. Totally 696 mosquitoes were collected which includes *Aedes aegypti*, *Ae. albopictus*, *Anopheles stephensi*, *Culex quinquefasciatus* and *Cx. tritaeniorhynchus*, etc. Discarded tyres, stagnant pools, and different types of containers are the main source of mosquito breeding. Tree holes are also important and neglected mosquito breeding sites in the study areas. Presence of *Aedes*, *Anopheles* and *Culex* mosquitoes indicates the disease prevalence. Information about the breeding habitats will be helpful to formulate a mosquito vector control strategy.

Keywords: Mosquito distribution, Diversity, Vellore, Tamilnadu, India.

INTRODUCTION

Mosquitoes not only vectors of etiological agents of many diseases that affect humans and other vertebrates, but also constitute a nuisance and cause allergies. The family Culicidae (Diptera) has approximately 3600 valid described species, which are widely distributed in most environments on the planet (Harbach, 2014). In India, about 410 species have already been reported (WHO, 2014). These include *Anopheles stephensi*, an important vector of malaria, *Aedes aegypti*, a vector of dengue, and *Culex quinquefasciatus*, a vector of bancraftian filariasis besides other species involved in the transmission of arboviruses (Senthamarai Selvan *et al*., 2015a).

Mosquitoes breed in various habitats such as ponds, marshes, ditches, pools, drains, water containers and other similar water collections like tree holes different genera of mosquitoes having specific breeding preference (Jebanesan, 2013; Senthamarai Selvan *et al*., 2015b). The abundance of mosquitoes is strongly influenced by density-dependent patterns and seasonal climate variations. Changes in climate may accelerate (or) delay in the development, availability of breeding sites and food resources (Franklin and Whelan, 2009). Dengue is considered as an important public health problem in India. Major epidemics have been reported from different parts of India. Dengue viruses are transmitted mainly by the mosquitoes *Ae. aegypti* (urban vector) and *Ae. albopictus* (rural vector).

Unplanned urbanization, particularly in the last decades of the 20th century, the Vellore city is currently suffering environmental and social stress, including excessive paving, air and noise pollution, population densification, social exclusion and violence. Adequate knowledge of diversity of mosquito population, preferential habitat selection of vector species and their distribution will help to evolve a suitable strategy to control mosquito population and there by prevent the outbreak of mosquito borne diseases. The present study has examined to study the diversity of mosquitoes in Vellore district.

MATERIALS AND METHODS

Study Area

Entomological surveys were conducted in Vellore district, in a total of 10 different pockets (either villages or areas in town or panchayath) under five randomly selected taluks viz., Arakkonam, Katpadi, Gudiyatham, Vellore and Thirupattur (Figure 1). Vellore is located at 133 km away from Chennai metropolitan city. Vellore is one of the developing city of Tamilnadu located between 12^0 15' to

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13^0 15' North latitude and 78^0 20' to 79^0 50' East longitude. The city has an average elevation of 216 m above the mean sea level. The total area of Vellore district is 6077 km^2.

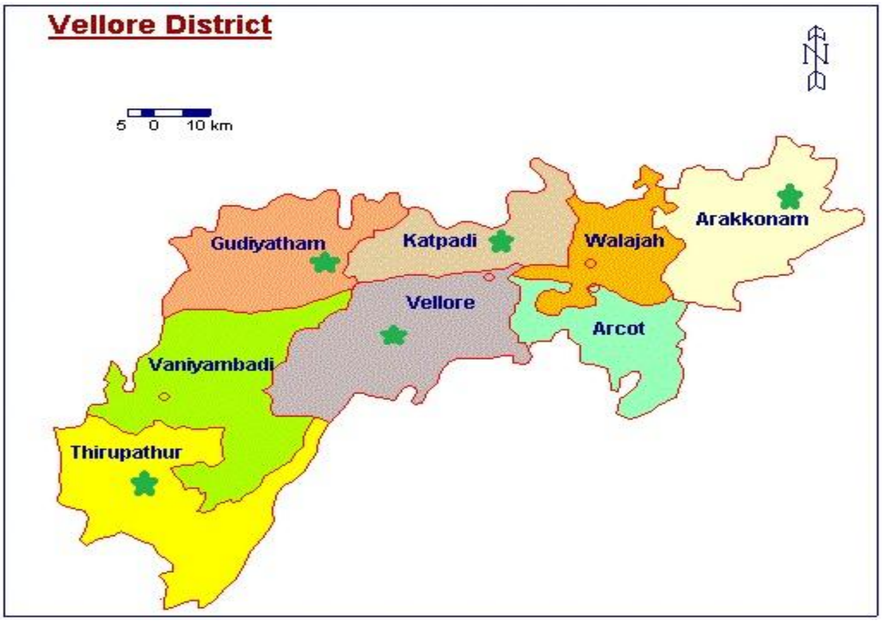

Figure 1. Study areas of Vellore district.

Entomological Survey

The habitats sampled include containers, stagnant pools, discarded tyres, cess pits, domestic runoffs and tree holes etc. Habitat evaluation method as described by Service (1993) was adopted in collecting the larvae from different habitats. The adult mosquitoes were collected with the help of suction tube and sweep net. Mosquito collections were carried out at dawn (06:00-09:30) and dusk (18:00-21:30) hours in frequently twice per month between July, 2015 - December, 2015. The collected mosquitoes were identified to species level by identification keys and nomenclature (Christophers, 1993; Barraud, 1943).

Data Analysis

Diversity studies (alpha diversity) were conducted by calculating, Simpson's (1949) Dominance Index (λ) = $1/\sum (Pi^2)$ and Shannon-Wiener (1949) Diversity Index (H') = $-\sum pi$ In (Pi) Shannon-Weaver diversity index is commonly used to characterize species diversity in a community, according to both abundance and eveness of the species present.

RESULTS

The rapid spread of *Aedes* spp. in Vellore district was due to storage of water in plastic containers and wasted coconut shells. During the study period totally 10 species of 696 mosquitoes were collected belonging to four genera *Aedes*, *Culex*, *Anopheles* and *Ochlerotatus*. These comprised of three species of *Aedes*, three species of *Culex*, three species of *Anopheles* and one species of *Ochlerotatus* (Table 1 and 2). Both artificial and natural containers were surveyed as potential mosquitoes breeding in Vellore district at five different randomly selected taluks viz., Arakkonam, Katpadi, Gudiyatham, Vellore and Thirupattur. Among them 107 containers were found positive, in which coconut shell and plastic containers are having the more mosquitoes occurrence followed by tree holes and cattle sheds (Table 4). The outdoor environment was found to be the best breeding habitats for mosquitoes especially dengue and chickungunya, because of filling of the containers with the rain water in wasted plastic containers, coconut shells, and discarded tyres and storage of water in plastic drum by the people.

In the present study, *Ae. aegypti* and *Cx. quinquefasciatus* was found to be the predominant species in Vellore whereas *Cx. vishnui* and *Ae. albopictus* was the predominant species in Arakonam and Gudiyattaum closely followed by *An. subpictus* (Table 5). The high prevalence of *Ae. aegypti* and *Cx. quinquefasciatus* in Arakonam, Vellore and Gudiyattam may be attributed to the presence of wasted coconut shells and plastic containers. These collected rain waters offer an ideal breeding ground for mosquitoes. Similar observations have been made by Rajesh *et al*., (2013) who found the *Ae. aegypti* breeding commonly in rain water collections as well as in container habitats like tree holes and coconut shells.

In overall survey of Vellore district in a randomly selected sites of taluks, *Ae. aegypti* is the predominant species in Thirupattur and Katpadi and showed a trend of increase in August (68) and December (46), 2015 followed by *Cx. quinquefasciatus*. Maximum number of *An. subpictus* were recorded in December (24), 2015 and October (14), 2015. Overall population of mosquitoes collected in Vellore district were peak in December (182), 2015 and also August (136), 2015 followed by November (119), 2015 (Table 3).

The highest Simpson's dominance index value of 0.1593 followed by 0.1496 was recorded in Vellore taluk of Vellore district as *Aedes aegypti* and *Culex quinquefasciatus* respectively. Simpon's dominance index values are recorded 0.1548 as *Aedes aegypti*. In Arakonam taluk the highest Shannon-Weiner diversity value are recorded as *Aedes aegypti* (0.1555) during the month of July, 2015 to December, 2015 (Table 6). The least value 3.703 was recorded in Tirupattur study site. *Ae. aegypti* and *Cx. quinquefasciatus* was the most frequent species in all the study sites and having more in Vellore followed by Thirupattur. The least mosquitoes were observed in Katpadi study site of Vellore district, the highest Shannon and Simpson's values are 0.1590, 0.0003 (*Cx. quinquefasciatus*) respectively. From this investigation, it is clear that there are many chances at mild dengue chickungunya viral infection spreading in the sampling locations.

Table 1. Species richness of mosquitoes collected in Vellore district during July, 2015 to December, 2015.

S. No	Name of the species	Total	Percentage (%)
1	*Aedes aegypti*	216	31.03
2	*Ae. albopictus*	72	10.34
3	*Ae. stokesi*	16	2.29
4	*Culex quinquefasciatus*	135	19.39
5	*Cx. vishnui*	75	10.77
6	*Cx. tritaeniorhynchus*	25	3.59
7	*Anopheles subpictus*	63	9.05
8	*An. stephensi*	58	8.33
9	*An. culicformis*	18	2.58
10	*Ochlerotatus pseudotaeniatus*	18	2.58
	Total	696	100

Table 2. Occurrence of mosquito species in various regions of the study area during the study period (July, 2015 – December, 2015).

S. No.	Name of the species	Vellore	Arakonam	Katpadi	Gudiyattam	Thirupattur
1	*Aedes aegypti*	+	+	+	+	+
2	*Ae. albopictus*	+	+	-	+	-
3	*Ae. stokesi*	-	+	-	+	+
4	*Culex quinquefasciatus*	+	+	+	+	+
5	*Cx. vishnui*	+	+	+	-	+
6	*Cx. tritaeniorhynchus*	-	-	+	-	+
7	*Anopheles subpictus*	-	+	+	-	+
8	*An. stephensi*	+	+	-	+	+
9	*An. culicformis*	-	-	-	+	-
10	*Ochlerotatus pseudotaeniatus*	-	+	-	+	-
	Total	310	202	27	96	61

+ = Present, - = Absent.

Table 3. Month wise diversity of Mosquitoes recorded in the study area during the study period (July, 2015 – December, 2015).

S. No.	Name of the Species	Jul	Aug	Sep	Oct	Nov	Dec	Total
1	*Aedes aegypti*	21	68	24	19	38	46	216
2	*Ae. albopictus*	8	3	13	12	15	21	72
3	*Ae. stokesi*	-	6	-	8	2	-	16
4	*Culex quinquefasciatus*	18	33	19	10	22	33	135
5	*Cx. vishnui*	7	10	16	12	10	20	75
6	*Cx. tritaeniorhynchus*	-	2	7	6	9	11	25
7	*Anopheles subpictus*	4	12	1	14	8	24	63
8	*An. stephensi*	5	2	9	8	15	19	58
9	*An. culicformis*	-	-	-	5	7	6	18
10	*Ochlerotatus pseudotaeniatus*	-	-	11	2	3	2	18
	Total	63	136	100	96	119	182	696

Table 4. Distribution of Mosquitoes in Vellore district during the study period (July, 2015 – December, 2015).

S. No.	Name of the Container	No. of Containers Searched for Mosquitoes	No. of Containers Positive for Mosquitoes	Vellore		Arakonam		Thirupattur		Gudiyattam		Katpadi	
				N	P	N	P	N	P	N	P	N	P
1	Plastic containers	25	21	5	5	5	3	5	5	5	3	5	5
2	Discarded tyres	11	9	2	2	1	-	3	2	2	2	3	3
3	Mud pot	7	4	2	1	1	-	2	2	-	-	2	1
4	Tree holes	31	16	6	3	10	5	5	3	5	1	5	4
5	Stagnant pools	4	2	1	-	-	-	-	-	1	-	2	2
6	Coconut shell	42	33	8	6	5	3	11	9	13	11	5	4
7	Overhead tank	6	2	2	-	-	-	2	1	-	-	2	1
8	Cess pit	17	7	3	2	2	1	8	4	-	-	4	-
9	Unused well	4	1	-	-	-	-	2	1	2	-	-	-
10	Cattle shed	19	12	5	2	2	-	-	-	2	2	10	8
	Total	166	107	34	21	26	12	38	27	30	19	38	28

N= No. of containers searched for Mosquitoes.
P= No. of containers positive for Mosquitoes.

Table 5. Mosquito population in Vellore district during July, 2015-December, 2015.

S. No.	Name of the Species	Name of the Taluks					Total
		Vellore	Arakonam	Thirupattur	Gudiyattam	Katpadi	
1	*Aedes aegypti*	122	58	22	8	6	216
2	*Ae. albopictus*	28	22	-	22	-	72
3	*Ae. stokesi*	-	6	-	6	4	16
4	*Culex quinquefasciatus*	76	25	11	14	9	135
5	*Cx. vishnui*	26	13	17	15	4	75
6	*Cx. tritaeniorhynchus*	-	21	-	1	3	25
7	*Anopheles subpictus*	13	39	11	-	-	63
8	*An. stephensi*	45	7	-	1	1	58
9	*An. culicformis*	-	-	-	-	-	18
10	*Ochlerotatus pseudotaeniatus*	-	11	-	-	-	18
	Total	310	202	61	96	27	696

Table 6. Diversity index of the mosquitoes collected from Vellore district during the study period (July, 2015 – December, 2015).

Name of the Mosquitoes	fi	Pi	ni(ni-1) / N(N-1)	Shannon Weiner Index H=(N log N - ∑ fi log fi / N	Simpson's Index $C=\sum (ni/N)^2$
Vellore					
Ae. aegypti	122	0.3935	0.1541	0.1593	0.1548
Ae. albopictus	28	0.0903	0.0078	0.0943	0.0081
Cx. quinquefasciatus	76	0.2451	0.0595	0.1496	0.0601
Cx. vishnui	26	0.0838	0.0067	0.0902	0.0070
An. subpictus	13	0.0419	0.0016	0.0577	0.0017
An. stephensi	45	0.1451	0.0206	0.1216	0.0210
Total	310	0.9961	0.2503	0.6727	0.2447
Arakonam					
Ae. aegypti	58	0.2871	0.0814	0.1555	0.0824
Ae. albopictus	22	0.1089	0.0113	0.1048	0.0118
Ae. stokesi	6	0.0297	0.0007	0.0453	0.0088
Cx. quinquefasciatus	25	0.1237	0.0147	0.1122	0.0153
Cx. vishnui	13	0.0643	0.0038	0.0766	0.0041
Cx.tritaeniorhynchus	21	0.1039	0.0103	0.1021	0.0108
An. subpictus	39	0.1930	0.0365	0.1378	0.0372
An. stephensi	7	0.0346	0.0010	0.0505	0.0012
Oc. pseudotaeniatus	11	0.0544	0.0027	0.0687	0.0029
Total	202	0.9996	0.1624	0.8535	0.1718
Thirupattur					
Ae. aegypti	22	0.3606	0.1262	0.1597	0.1300
Cx. quinquefasciatus	11	0.1803	0.0300	0.1341	0.0325
Cx. vishnui	17	0.2786	0.0743	0.1546	0.0776
An. subpictus	11	0.1803	0.0300	0.1341	0.0325
Total	61	0.9998	0.2605	0.5825	0.2726
Gudiyattam					
Ae. aegypti	8	0.0833	0.0061	0.0899	0.0069
Ae. albopictus	22	0.2291	0.0506	0.1466	0.0525
Ae. stokesi	6	0.0625	0.0032	0.0752	0.0039
Cx. quinquefasciatus	14	0.1458	0.0199	0.1219	0.0212
Cx. vishnui	15	0.1562	0.0230	0.1259	0.0244
Cx. tritaeniorhynchus	1	0.0104	0.0000	0.0206	0.0001
An. subpictus	1	0.0104	0.0000	0.0206	0.0001
Total	96	0.6977	0.1028	0.4748	0.1091
Katpadi					
Ae. aegypti	6	0.2222	0.0427	0.1451	0.0493
Ae. albopictus	4	0.1481	0.0170	0.1228	0.0219
Cx. quinquefasciatus	9	0.3333	0.1025	0.1590	0.1111
Cx. vishnui	4	0.1481	0.0170	0.1228	0.0219
Cx. tritaeniorhynchus	3	0.1111	0.0085	0.1060	0.0123
An. stephensi	1	0.0370	0.0000	0.0529	0.0013
Total	27	0.9998	0.1877	0.7086	0.2178

fi-number of species, Pi-proportion of individuals found in the species, N-total number of individuals.

DISCUSSION

Vellore district is endemic for dengue and chikungunya in last few years filarial and some viral fever has been a regular occurrence after the rainy season especially in unplanned urbanized areas. Among the collected vector species the adult *An. subpictus* is zoophilic and is considered as vector of Japanese encephalitis in Karnataka, Kerala and Tamilnadu (George *et al*., 1987; Thenmozhi *et al*., 2006). The adult *Ae. albopictus* also known as 'Asian tiger mosquito' is vector of chickungunya and dengue (WHO, 2002). Generally as wild species they breed in rock hole and tree holes in forest areas but due to deforestation this mosquitoes now adapted to breed in discarded tyres in many parts of India (Baskara Rao and Biju George, 2010). Among the genus *Culex*, the *Cx. vishnui* is zoophilic and outdoor resting and are considered JE vector in India, Malaysia and Taiwan and are widely distributed in rural areas (CDC, 2004).

Dengue virus is a mosquito-borne flavivirus and the most prevalent arbovirus affecting the tropical and subtropical regions of the world (Senthamarai Selvan and Jebanesan, 2015c). The incidence of the disease has increased over the last 50 years with 2.5 billion people living in areas where dengue is endemic (Gubler, 1997). It affects up to 100 million people each year, with 500,000 cases of dengue haemorrhagic fever (DHF) and dengue shock syndrome (DSS) and around 30,000 deaths, mostly amongst children (Guzman and Kouri, 2002). In recent years, dengue fever and its more serious forms, DHF and DSS, have emerged as a major public health problem with expanded geographic distribution and increased epidemic activity (WHO, 1999).

Urbanization is a continuous process in developing countries like India and this has naturally led to aggregation of population. Further, due to rapid industrialization, large numbers of labourers migrate from rural to urban areas in search of job opportunities. This has resulted in the development of many slums with no proper sanitary and waste water disposal arrangements. Due to unplanned town expansion, the peripheral areas of towns bordering villages have become semi-urbanized and this process continues unchecked. The results are environmental changes including the creation of water bodies highly conductive for the breeding of mosquitoes. The increasing breeding potential at these ubiquitous mosquitoes can thus be attributed to the development process (Senthamarai Selvan *et al.,* 2016; Manimagalai, 2010).

Aedes aegypti is the principal dengue vector of urban areas (Rudnick *et al*., 1965). The larvae of *Ae. aegypti* were collected more in number and they usually breed in stagnant and polluted water with high organic contents which placed *Ae. aegypti* species as anthropophilic in nature (Hidayati *et al*., 2005; Mariappan, 2013). Drinking water scarcity in the affected area was the main reason for the storing of water in the households which supported the profuse breeding of vector species. Similar observations were also made by earlier reported surveys carried out in Tamilnadu (Philip Samuel *et al*., 2009; Miswar Ali *et al*., 2014).

Chatterjee *et al*. (1988) while conducting a survey in metro rail construction sites in Kolkata of West Bengal found that, Aedes and Culex mosquitoes mainly preferred rain water for breeding in winter and post-winter. The habitat preference by Aedes species has found to be similar as described by earlier studies (Senthamarai Selvan et al., 2015b; Rajesh et al., 2013; Chen et al., 2009). The major breeding habitats of Aedes mosquitoes are both natural and artificial containers such as plastic containers, cemented tanks, temporary pools, etc.

Human ecology is responsible for the creation of a mosquitogenic environment, man directly or indirectly creating such a situation (Senthamarai Selvan and Jebanesan, 2014a & b). Containers are probably the most important factor determining the breeding of *Aedes* and *Anopheles* species. Since artificial containers are the major larval habitats in and around human habitations. A thorough study at different point of the stream at higher and lower elevations revealing the possible breeding places of the vector mosquitoes and suitable actions may be taken along with the health department to control the vector mosquitoes.

CONCLUSION

In the present study peak mosquito population was recorded December month and population was gradually increased from November to December, 2015. The source reduction is an effective way for the community to manage the populations of many kinds of mosquitoes. The eradication of mosquito breeding containers or breeding sites in and around living, working areas should be taken into consideration, since the presence of water in containers is probably the most important factor in determining the breeding of mosquitoes, especially *Aedes* spp. (Senthamarai Selvan *et al*., 2013).

Important of this study cannot be overemphasized in formulating control strategies against this important mosquito vector through proper environment planning and management that will help in reducing breeding habitat. Adequate knowledge of diversity of mosquito population, preferential habitat selection of vector species and their distribution will help to evolve a suitable strategy to control mosquito population and there by prevent the outbreak of mosquito borne diseases like dengue, chickungunya, etc.

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