https://doi.org/10.33307/entomon.v45i1.498
ENTOMON 45(1): 07-14 (2020)
Article No. ent. 45102

Prevalence of *Stegomyia albopicta* (Skuse) (Diptera: Culicidae), in Dakshina Kannada district of Karnataka, India

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ABSTRACT: Dengue is one of the rapidly spreading mosquito-borne diseases transmitted worldwide by the bites of infected *Stegomyia aegypti* and *St. albopicta* mosquito. Both species are adapted for human habitation and breeds mainly in temporary water bodies. In the present study, a preliminary larval survey was carriedout in four different localities of Dakshina Kannada District. Of the 1094 suspected water bodies, 496 sites showed the presence of *St. albopicta* larvae and none of them showed the presence of *St. aegypti* indicating the dominance of the former species. The occurrence of *St. albopicta* was significantly higher in natural phytotelmata compared to artificial containers. Among the different breeding sites, receptacles contributed 24.5% of larval positivity. The receptacles also showed a higher breeding preference ratio (1.56) indicating that abandoned waste thrashes when receives water may act as the most preferred breeding sites for dengue vector species.

KEYWORDS: Dengue, *Stegomyia mosquito*, habitats, receptacles

INTRODUCTION

Dengue is a widespread mosquito-borne disease prevalent throughout the tropics, with confined variations in risk influenced by unplanned urbanization. Globally approximately 3.9 billion people, in 128 countries are at the risk of infection with an estimated 390-500 million cases of dengue occurring every year (Brady *et al*., 2012; Gubler, 2012; Bhatt *et al*., 2013). *Stegomyia albopicta* (Skuse) (=*Aedes albopictus*), as a container breeding vector species of mosquito breeds both in natural and man-made water bodies. The species is considered as a reservoir vector of dengue especially in rural areas of dengue-endemic countries of South-east Asia and the Pacific islands (Tandon and Raychoudhury 1998). Globally, *St. aegypti* is considered as a primary vector and *St. albopicta* as a secondary vector of dengue fever (Sharma *et al*., 2014). The water storage system can provide easy breeding sites for these mosquitoes which may further enhance the disease transmission. Among the two dengue vectors, the *St. albopicta* out competes with *St. aegypti* because of its great adaptability and aggressive nature. In several parts of Kerala, *St. albopicta* carrying dengue virus, that too in the absence of *St. aegypti*, was reported (Tyagi, 2006). Studies also have shown that *St. albopicta* can play a significant role

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in the vertical transmission of dengue fever (Vazeille *et al*., 2003; Thenmozi *et al*., 2007).

The dengue virus (DENV) is an RNA virus with DENV1-4, four serologically and genetically distinguished serotypes. These four serotypes may involve multiple sequential infections which may further increase the magnitude of dengue epidemics (Shet and Kang, 2019). Dengue virus (DENV) infection of a human or mosquito host produces a dynamic population of closely related sequences. Such intra-host genetic diversity is thought to provide arboviruses an advantage for adapting as they pass between two very different host species (Sim *et al*., 2015). Over the past several decades, the dengue scourge march of mankind has expanded relentlessly, affecting more than 120 countries, putting more than four billion people at risk of dengue infection (Bhatt *et al*., 2013). In India, the earlier studies have shown that *St. aegypti* cause dengue transmission in cities and *St. albopicta* causes dengue transmission in suburban and rural areas (Delette *et al*., 2009).

The vector capacity of *St. albopicta* is well documented from different parts of Kerala carrying mainly dengue and chikungunya arboviruses (Thenmozhi *et al*., 2007; Regu *et al*., 2008; Sumodan, 2008). Change in the breeding pattern from the forest habitats to domestic ecotypes combined with aggressive diurnal human-biting behavior, ability to transmit a variety of viruses and occupation in the majority of temporary water bodies made this species not only dominant but highly dangerous especially in Southern India (Paulraj *et al*., 2016; Benedict *et al*., 2017). Widespread deforestation and increase in plantations especially rubber, cocoa and areca in forest-fringed hills contributed to the quick invasion of the *Stegomyia* species in Kerala and coastal districts of Karnataka. Due to the ecological adaptability, it entered into the rural and suburban niches, breeding extensively in rubber latex cup, receptacles, tanks, tires, shed leaf sheaths of areca palms, cocoa and other empty fruit pods (Hiriyan and Tyagi, 2004).

In Dakshina Kannada district, higher incidence of dengue has been reported in recent years (Fig. 1). Detection of larval habitats is essential for the identification of potential breeding grounds of the vector species and thus to recognize the source for the prevalence of the disease. Among the different components of dengue control, surveillance of vector species through larval and pupal collections is an important tool in disease epidemics and post-operational managements (Runge-Ranzinger *et al*., 2016). Since the semi-urban and rural areas of the different taluks are contributing the greater part of the dengue cases in the district, larval surveillance on the occurrence and breeding preference of the dengue vector has been carried out from the selected rural and semi-urban localities of the district.

MATERIALS AND METHODS

Larval Sampling: The monthly sampling was carried out from June 2016 to May 2017 in four localities of Dakshina Kannada district namely, Mudipu (12°48’10.06"N 74°57’50.98"E) (rural), Vitla (12°45’46.13"N 75° 6’5.15"E) (semi-urban) of Bantwal taluk and Kabaka (12°46’56.42"N 75° 9’41.54"E) (rural), Uppinangady (12°50’11.92"N 75°15’13.13"E) (semi-urban) of Puttur taluk respectively. In Dakshina Kannada, the average annual precipitation was 4,030 mm with the highest of 3037 mm of rain recorded during the monsoon season. The average humidity ranged from 62% to 89% and the mean temperature ranged from 20.8 to 34.0°C. Amongst a notable variety of microhabitats that retain water and supports aquatic stages of mosquito, 15 probable types were examined for the survey which were categorized as natural phytotelmata and artificial containers (Table 1).

The habitat preferences of *St. albopicta* for each type of positive breeding sites were assessed by calculating Breeding Preference Ratio (BPR) (Sharma, 2002) using the following formula:

$$\text{BPR } (Y\%/X\%) = \frac{\%\text{ of positive breeding sites } (Y\ \%)}{\%\text{ of the examined breeding sites } (X\ \%)}$$

Where,

$$X\% = \frac{\text{No. of a particular type of breeding sites examined}}{\text{Total breeding sites examined}} \times 100$$

$$Y\% = \frac{\text{No. of a particular type of breeding sites positive for } \textit{St. albopicta}}{\text{Total positive breeding sites examined}} \times 100$$

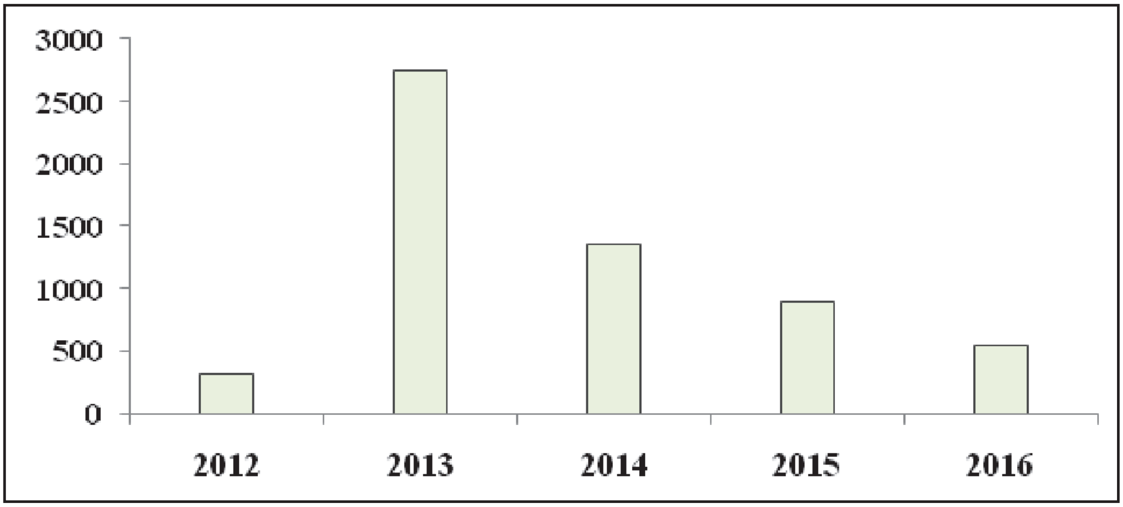

Fig. 1. Number of dengue incidences in Dakshina Kannada district (District Health Office Report)

Table 1. Classification of *St. albopicta* breeding sites surveyed in Dakshina Kannada district.

Sl.No	Natural containers of phytotelmata origin	Sl.No	Artificial containers
1.	Leaf axils	1.	Receptacles#
2.	Tree-holes	2.	Tires
3.	Bamboo stump	3.	Cement cistern with vegetation
4.	Fallen leaf	4.	Cement Water storage tanks
5.	Areca sheath	5.	Plastic water storage containers
6.	Coconut husks or shells	6.	Cesspits
7.	Cacao pods	7.	Latex cup
8.	Tree logs		

#discarded solid waste such as bottles, cans, plastic and metal containers, etc.

The differences in the occurrence of *Stegomyia* larvae between artificial and natural sites were statistically analyzed using the Chi-square test. Further, for artificial containers sampled from the residential area, container index (CI) was also calculated as per the WHO guidelines (2003).

In each locality, approximately 500m^2 area covering residential and areca plantation areas were surveyed to detect *Stegomyia* larval breeding. In residential sampling sites, water bodies in and around the cowsheds, dairy farms, poultry farms were also surveyed as these places provide plenty of hosts for blood-feeding which may influence the oviposition of the mosquito. The larval collections were made using dipping and pipetting methods. Only those water samples which showed the occurrence of *Stegomyia* larvae and pupae were transferred to a plastic bottle marked with a label and then taken to Zoology laboratory, Vivekananda College, Puttur for further processing. The identification of species was mainly based on the morphological characters of both larvae and adult specimens using a standard key (Barraud, 1934). Further, the confirmation of species was done by the hypopygium mounting of the adult male (Huang, 1979). The latest abbreviations of generic names provided by Reinert (2009) were used in the study.

RESULTS AND DISCUSSION

Of the 15 different types of water bodies surveyed, *St. albopicta* was documented from 14 types of breeding sites except cesspits (figure 2). From a total of 1,064 water-holding sites surveyed, constituiting 49.2% phytotelmata and 50.8% artificial containers surveyed 494 sites with 46.42% had *St. albopicta* larvae. Of the preferred habitats, receptacles contributed highest of 24.49% (n=121) followed by areca sheath with 20.64% (n =102) and tyres with 10.52% (n=52). Studies have shown that *Stegomyia* mosquito thrives well in discarded and unused receptacles and water collected in the plant materials especially during the rainy season (Samuel *et al*., 2014). *St. albopicta* was abundantly collected from peridomestic containers and water bodies associated with plantations from the hilly regions and rural areas of Kerala state (Eapen *et al*., 2010).

The number of breeding sites varied in different seasons. In monsoon, 300/557 (53.8%) sites including 145 phytotelmata and 155 artificial containers showed larval presence. In post-monsoon, 149/313 (47.6%) sites including 85 phytotelmata and 64 artificial containers showed the presence of dengue larvae. However, in the pre-monsoon period, only 45/194 (23.19%) showed the larval existence. *St. albopicta* was more dependent on rainfall and its larval density sharply increased with the onset of monsoon rains which filled up the peridomestic containers and phytotelmata spread in the area. During monsoon season, areca plantations with abandoned receptacles, area sheath and other plant materials such as leaves, pods have been found to be excellent breeding sites for the proliferation of the vector species. Human dwellings and grazing cattle in the surrounding area of the plantations provides easy blood meal. Dengue vectors were reported during both pre-and post-monsoon seasons at higher altitudes of Western Ghats (Ravikumar *et al*., 2013).

Among the water bodies, the occurrence of *St. albopicta* larvae was found to be 42.54% and 51.26% in artificial containers and natural phytotelmata respectively. The prevalence of *St. albopicta* showed a significant difference in natural and artificial habitats (÷2=8.01, P<0.05). The *St. albopicta* has greater adaptability to breed in domestic as well as natural water bodies. Being originally a forest species, it rapidly adapted to human habitation as a container breeder due to widespread deforestation and conversion of forest into agricultural settlements. Due to the rapid invasiveness, it spread to rural and suburban niches

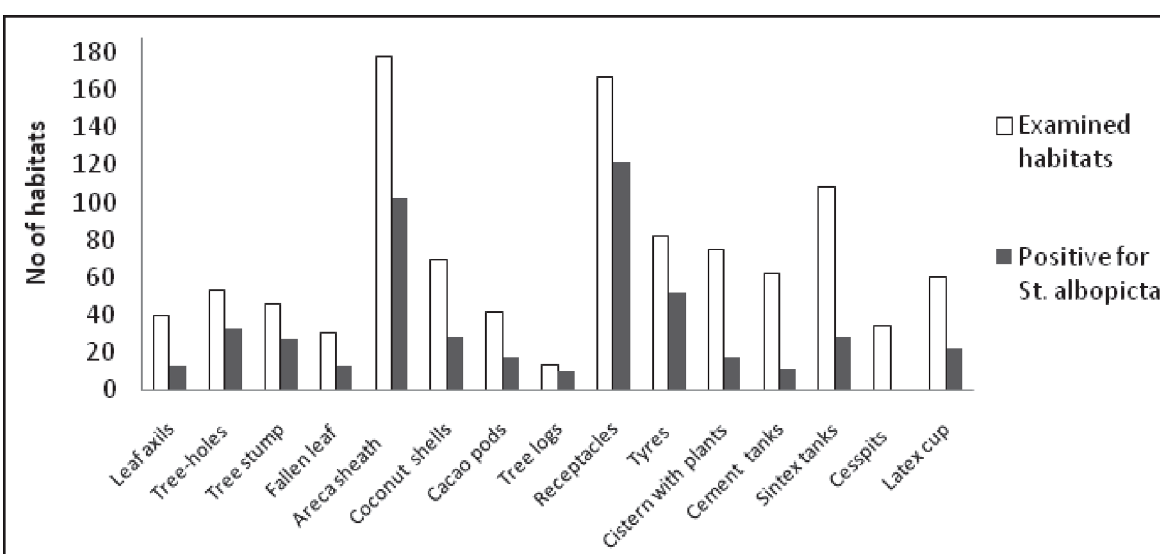

Fig. 2. Breeding sites surveyed for the occurence of *St. albopicta*

Table 2. Breeding preference ratio (BPR) of *St. albopicta* in different breeding sites of Dakshina Kannada district

Types of breeding habitats		No. of breeding sites		% X	% Y	BPR (%Y / %X)
		Examined (X)	Positive for *St. albopicta* (Y)			
1	Leaf axils	40	13	3.75	2.63	0.7
2	Tree-holes	53	33	4.98	6.68	1.34
3	Tree stump	46	27	4.32	5.46	1.26
4	Fallen leaf	31	13	2.91	2.63	0.9
5	Areca sheath	178	102	16.72	20.64	1.23
6	Coconut shells	70	28	6.57	5.66	0.86
7	Cacao pods	42	17	3.94	3.44	0.87
8	Tree logs	14	10	1.31	2.00	1.54
9	Receptacles	167	121	15.69	24.49	1.56
10	Tires	82	52	7.7	10.52	1.36
11	Cistern with plants	75	17	7.04	3.44	0.48
12	Cement tanks	62	11	5.82	2.22	0.88
13	Sintex tanks	109	28	10.24	5.66	0.55
14	Cesspits	34	0	3.19	0	0
15	Latex cup	61	22	5.73	4.45	0.77
	Total	1064	494			

breeding in artificial containers like plastics and tyres. The concomitant destruction of natural habitats forced the species to breed in domestic containers besides natural sites (Almeida *et al*., 2005). In the neighboring state of Kerala, the larval occurrence was reported from several phytotelmata bodies such as areca sheaths, coconut pods, tree holes, leaf axils (Rao, 2010). The acclimatization of *St. albopicta* to breed in water collected in phytotelmata bodies was found to be a serious concern, as these structures provide stable oviposition sites for the prevalence of mosquito species even in the dry seasons (Eapen *et al*., 2010).

The Breeding Preference Ratio (BPR) has also been computed for the *St. albopicta* recorded in the study area (Table 2). Receptacles (1.56) i.e. discarded containers were found to be the most preferred breeding sites followed by logged trees (1.54), tyres (1.36) and tree holes (1.34). Water in these containers is stored for longer durations mainly because of rainfall, making them as productive breeding grounds. The earlier studies have indicated that the discarded utensils have higher BPR compared to that of the containers used for water storage (Singh *et al*., 2008, 2011). Tyres are particularly useful oviposition sites, as they are often stored outdoors and collect and retain rainwater effectively for a long time. Along with these, the addition of decaying leaves and other organic matters produces similar environmental conditions to tree holes, which provide an excellent substratum for breeding (Kweka *et al.,* 2018). The earlier studies have shown that *St. albopicta* may use natural phytotelmata to breed and thrive in non-urbanized areas, increasing more public health concerns in rural areas. Careless dumping of waste plastic, thermacol and metallic containers in and around the houses may cause a major problem, especially in monsoon season, as these eventually become the breeding ground for the mosquito larvae. The BPR is low (0.48) for cistern with plants indicating the lesser preference of *Stegomyia* larvae to permanent water bodies. The container index was maximum in monsoon (56.77) followed by post-monsoon (39.75) and pre-monsoon (20.51).

The *St. albopicta* was found to co-exist with 10 species of mosquitoes namely *Anopheles stephensi, Armigeres subalbatus, Ar. aureolineatus, Fredwardsius vittatus, Culex quinquefasciatus, Cx. tritaeniorhynchus, Cx. gelidus, Cx. nigropunctatus, Cx. mammilifer* and *Toxorhynchites splendens* in different breeding sites. In recent years, studies have documented the co-occurrence of Stegomyia larvae with some species of Anopheline and Culicine larvae (Chen *et al*., 2006; Wan-Norafikah *et al*., 2009; Rohani *et al*., 2010). The coexistence of *St. albopicta* with *St. aegypti, Ar. subalbatus* and *Cx. quinquefasciatus* in tree holes and in trashed water bottles indicate that vector species in different breeding sites can share the habitats (Hawley, 1988; Sultana *et al*., 2017). But this co-occurrence of multiple species dependent on the habitat types, mosquito species and other physicochemical parameters of the water bodies.

From the present larval surveillance, it can be concluded that *St. albopicta* is a well-established species in the district especially in rural areas with the highest occurrence during monsoon season. The higher occurrence of larvae in phytotelmata associated with plantations may be one of the main reasons for the higher incidences of dengue fever in rural areas. Interestingly, in none of the habitats, the existence of *St. aegypti* has been reported indicating the dominance of species *St. albopicta* and the role of *St. albopicta* as the vector of dengue and chikungunya (Paulraj *et al.,* 2016). A similar survey carried out in the Lakshadweep islands, revealed the predominance of *St. albopicta* and the absence of *St. aegypti*. Early studies indicate that the decline and virtual disappearance of *St. aegypti* in rural and suburban areas by *St. albopicta* is due to the competitive displacement which occurs mainly due to the breeding preference of former species in natural habitats (Black *et al*., 1989). Climate change is one of the key factors responsible for the rapid expansion of *St. albopicta* (Roiz *et al*., 2011; Proestos *et al*., 2015). *St. albopicta* found to be one of the most aggressive outdoor species, and their day-biting behaviour aided by very broad host range including humans, domestic animals, amphibians, reptiles, and birds makes the species an important susceptive vector for dengue fever (Eritja *et al*., 2005). So it is very much obligatory to tackle this mosquito species before it takes the district to yet another dengue disease epidemic condition.

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(Received October 05, 2019; revised ms accepted February 03, 2020; printed March 31, 2020)