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R Rajendran
Consultant, Additional Director & Head, Research Assistant, Research Assistant & Technician National Centre for Disease Control, Calicut, Kerala, India

K Regu
Consultant, Additional Director & Head, Research Assistant, Research Assistant & Technician National Centre for Disease Control, Calicut, Kerala, India

SB Anusree
Consultant, Additional Director & Head, Research Assistant, Research Assistant & Technician National Centre for Disease Control, Calicut, Kerala, India

Anila Rajendran
Consultant, Additional Director & Head, Research Assistant, Research Assistant & Technician National Centre for Disease Control, Calicut, Kerala, India

W Tamizharasu
Consultant, Additional Director & Head, Research Assistant, Research Assistant & Technician National Centre for Disease Control, Calicut, Kerala, India

Corresponding Author:
R Rajendran
Consultant, Additional Director & Head, Research Assistant, Research Assistant & Technician National Centre for Disease Control, Calicut, Kerala, India

Seasonal surveillance of the vectors of yellow fever, dengue, chikungunya and zika in New Mangalore Sea Port, India

R Rajendran, K Regu, SB Anusree, Anila Rajendran and W Tamizharasu

Abstract
Aedes- borne virus diseases are fast spreading and pose significant health issues globally. The global spread of these diseases is being fuelled by globalization, unplanned urbanization, human migration, animal transportation and climatic changes. The International Health Regulations (IHR) advocates maintaining a vector free zone at ports, airports and ground crossings and 400 meter around these entry points. Vector surveillance and control at Points of Entry (PoE) is an essential activity in the successful implementation of IHR. Therefore, Vector surveillance was undertaken in and around New Mangalore Port Trust (NMPT) during the last week of May 2019 (Pre monsoon) and during the first week of November 2019 (Post monsoon). Inside the port, a total of 15 water holding containers at 40 premises were checked during Pre monsoon and no containers were found positive for *Aedes* larval breeding. However, in the Post monsoon surveillance, the Breteau index (BI) was found above the critical level. *Aedes* surveillance in the residential areas around NMPT showed that all the *Aedes* larval indices were below the critical level during both the seasons. In the present study it is evident that inside the port there are enough habitats for the profuse breeding of mosquitoes during rainy season. Routine entomological surveillance is required in and around seaport to prevent the invasion and establishment of vector mosquitoes.

Keywords: *Aedes*-borne viral diseases, vector surveillance, international health regulations

Introduction
The global resurgence and expanded distribution of *Aedes*-Borne Viral Diseases (ABVDs) such as dengue, chikungunya, zika and yellow fever has generated a renewed interest in the biology and control of *Aedes* (*Stegomyia*) mosquitoes in recent years. *Aedes*-borne virus diseases are fast spreading diseases that pose significant public health issues globally [1]. These viruses can be life-threatening. For instance, Dengue virus (DENV) alone currently infects approximately 390 million people annually with 96 million of these showing clinical manifestations [2]. Zika and chikungunya have caused abrupt epidemics in the Americas after recent introductions from Asia. Neurological complications from Zika virus infection led World Health Organization (WHO) to declare a public health emergency of international concern in February 2016. An outbreak of Zika virus infection was reported on 2018 in Rajasthan state, India. Prior to this outbreak, India reported four confirmed cases of Zika virus infection in 2017 in Ahmadabad, Gujarat state and one case in Krishnagiri district of Tamil Nadu [3]. Yellow fever (YF) outbreaks in urban areas of Africa during 2016 and in Brazil from 2016-2018 emphasis the continued risk of epidemic yellow fever to global public health.
Aedes-borne viruses (ABVs) are a subset of arboviruses that are mostly transmitted by female *Aedes aegypti* and sometimes by female *Aedes albopictus* mosquitoes [4]. *Ae. aegypti* is native to African forests, whereas *Ae. albopictus* is native to Asia. *Ae. aegypti* is confined to warm environments, where it proliferates mostly in man-made containers in and around the houses. *Ae. aegypti* shows a greater predilection for urban areas than *Ae. albopictus*. The anthropophilic and day time biting nature enabled *Ae. aegypti* to be a highly competent vector of dengue, chikungunya, Zika and yellow fever viruses [5]. *Ae. albopictus*, on the other hand, prefers to breed in rural and suburban settings and proliferates in man-made and natural containers with equal ease. In addition to humans, *Ae. albopictus* bites other mammals and birds. Hence it is considered to be a moderately competent vector for dengue, Zika,

chikungunya and yellow fever viruses [5].

The incidence of *Aedes*-borne diseases is increasing alarmingly due to rapid urbanization associated with urban growth. This can intensify favorable conditions for vector proliferation and dissipation [6]. In India, National Vector Borne Disease Control Program (NVBDCP) reported 75,808 dengue fever (DF) cases and 193 deaths during 2013 from 35 states/UTs. In the same year, in Karnataka 6408 DF cases and 12 deaths were reported. After five years, in 2019, the reported DF cases rose to 1, 57,315 and 166 deaths in India. Karnataka, on the other hand, reported 16,986 dengue fever cases and 13 deaths in 2019. There is an increase of 2.65 times DF cases in Karnataka over a span of five years. Similarly, 27,553 suspected and 3342 confirmed chikungunya cases were reported in 2015 from 30 states/UTs in India. In the same year, 20,763 suspected and 2099 confirmed chikungunya cases were reported from Karnataka state. After three years (in 2019), 81,914 suspected and 12,205 confirmed chikungunya cases were reported in India. The suspected and confirmed chikungunya cases reported in Karnataka in 2019 were 43,698 and 3664 respectively.

International travel and transport play an important role in the rapid spread of *Aedes*-borne diseases all over the world. The global development of the shipping industry and expansion of port cities has led to the global spread of *Aedes* mosquitoes. Moreover, India shares sea route/connection with majority of yellow fever endemic countries. To address the threat of *Aedes*-borne diseases in the points of entry (PoE) such as sea ports, air ports etc. WHO brought Member states under the umbrella of the International Health Regulations (IHR). This envisages that every port and its adjoining area within a perimeter of 400 meters should be kept free from immature and adult *Aedes* mosquitoes [7]. In order to ensure this, active mosquito surveillance and vector control measures are in place at the New Mangalore Port Trust (NMPT) area. As a cross check, entomological study was carried out by a team of experts from the National Centre for Disease Control (NCDC), Kozhikode, Kerala state in and around NMPT area.

Materials and Methods

Study area

New Mangalore Port is situated at Panambur, Mangalore in Karnataka state in India which is the deepest inner harbor in the west coast and is the only major port of Karnataka state and the seventh largest port in the country. The coordinates of the port are Latitude $12^{0}55^{1}$ North and Longitude $74^{0}48^{1}$ East. The port comprises of three doc systems via, Eastern Doc arm, Oil Doc arm and the Western Doc arm; it has in all 15 berths. The climate is governed by the monsoons. During the months June- September, the south-west monsoon occurs. The rest of the months are often indicated as the post-monsoon period. The hottest months are from March-May. The humidity is high throughout the year.

Residential area

Vector surveillance was undertaken around New Mangalore Port Trust area to assess the *Aedes* mosquito prevalence. Hundred houses were randomly selected in the NMPT staff quarters. There are altogether 708 houses – 391 houses in Type I to VII; 172 houses in Type A to D; 100 houses in Registered Cargo Handling Workers Colony (RCHWC) and 45 houses for CISF. The survey was done covering all the types of houses. The surroundings of each house premises were thoroughly checked to assess the favorable conditions for the breeding of vector mosquitoes and local hygiene conditions.

Entomological surveillance

Aedes survey was done in all the operational areas of NMPT area and in randomly selected 100 residential houses around the port on last week of May 2019 (pre-monsoon) and first week of November 2019 (post-monsoon). Standard entomological techniques were used for the survey. Larval survey was carried out in all types of water holding containers/premises to detect the breeding of vector mosquitoes especially *Aedes* (*Stegomyia*) mosquitoes in and around the port. All accessible larval breeding habitats-natural and man-made were inspected. The collected larvae were identified microscopically/ after adult emergence as per guidelines [8].

The type of breeding habitats in each premise was recorded on a pre designed proforma for classification. *Aedes* larval indices- House index / Premise index (HI/PI), Container index (CI), Breteau index (BI), the preferred breeding habitats and seasonal variation on vector breeding in and around NMPT area were analyzed.

Results and Discussion

Port area

Entomological surveillance was done at New Mangalore Port Trust (NMPT) area during first week of May 2019 (pre monsoon). A total of 15 water holding containers at 40 premises were examined, but no containers were found positive for *Aedes* breeding (Table 1). Of the total 15 water holding containers checked, 20.0% were plastic followed by discarded tires (80.0%). An attempt was made to classify the dry containers seen scattered in the premises of NMPT operational area. It has been noted that of the total 28 dry containers noted, 75% were discarded tires followed by metal (17.85%) and plastic (7.15%).

In order to assess to what extent the monsoon influences the *Aedes* larval productivity, vector surveillance was done during the first week of November 2019 in NMPT area. Of the 40 premises checked 02 were found positive for *Aedes* larvae (PI- 5.0%). A total of 28 containers with water at 40 premises were examined, 12 were found positive for *Aedes* larvae (CI-42.86%) and the Breteau index was 30.0, which was above the critical level (Table 2). Of the total water holding containers checked, 46.43% were metal followed by discarded tires (32.14%) and plastic (21.43%). Similarly, of the 12 *Aedes* positive containers, 58.33% were metal followed by discarded tires (32.33%) and plastic (8.33%). All the *Aedes* larval indices inside the port are above the critical level.

Table 1: Surveillance of *Aedes* mosquitoes at operational area of New Mangalore Port

Sl. No.	Premises	Pre monsoon						Post monsoon					
		Plastic		Metal		Tire		Plastic		Metal		Tire	
		S	P	S	P	S	P	S	P	S	P	S	P
1	Container yard	0	0	0	0	0	0	0	0	0	0	0	0
2	Hasan & Hajee company	0	0	0	0	0	0	0	0	0	0	0	0
3	Deployment office	0	0	0	0	0	0	1	0	1	0	0	0
4	Amogha logistics	0	0	0	0	0	0	0	0	0	0	0	0
5	Cochin shipping	0	0	0	0	0	0	0	0	0	0	0	0
6	Indian shipping agency	0	0	0	0	0	0	0	0	0	0	0	0
7	Asprin wall & Co	0	0	0	0	0	0	0	0	0	0	0	0
8	Sri Ganesh Shipping agency	1	0	0	0	1	0	2	1	2	1	0	0
9	World shipping agency	0	0	0	0	0	0	0	0	0	0	0	0
10	Export Trade link agency	0	0	0	0	0	0	0	0	0	0	0	0
11	Aiba-Asia behind	1	0	0	0	9	0	0	0	8	6	8	4
12	Iron or Coal Berth	0	0	0	0	0	0	0	0	0	0	0	0
13	Yojaka workshop	0	0	0	0	0	0	0	0	0	0	0	0
14-29	Berth No. 1 – XV (16 Premises)	0	0	0	0	0	0	1*	0	1**	0	0	0
30	Tug	0	0	0	0	0	0	0	0	0	0	0	0
31	Testing centre	0	0	0	0	0	0	2	0	0	0	0	0
32	Fire control area	0	0	0	0	0	0	0	0	0	0	0	0
33	Port fire station	0	0	0	0	1	0	0	0	1	0	1	0
34	NonVeg canteen	0	0	0	0	0	0	0	0	0	0	0	0
35	Veg canteen	0	0	0	0	0	0	0	0	0	0	0	0
35	Traffic & Customs	1	0	0	0	1	0	0	0	0	0	0	0
37	Foam pump house	0	0	0	0	0	0	0	0	0	0	0	0
38	Container yard	0	0	0	0	0	0	0	0	0	0	0	0
39	S.K.Transport	0	0	0	0	0	0	0	0	0	0	0	0
40	K.K. Gate	0	0	0	0	0	0	0	0	0	0	0	0
Total		3	0	0	0	12	0	6	1	13	7	9	4

S-Searched, P-Positive for *Aedes* larvae, * Noted from Berth No. IV, **Berth No. V.

Residential area

Aedes surveillance undertaken in randomly selected 100 houses around sea port area in pre monsoon showed that of the total 62 containers with water examined, 53.23% were plastic followed by cement (17.75%), earthen (12.90%), metal (6.45%), glass (6.45%), tire (1.61%) and grinding stones (1.61%). Only one container (plastic) was found positive for *Aedes* larvae. The House index (HI), Container index (CI) and Breteau index (BI) were found to be 1.0%, 1.6% and 1.0% respectively (Table 2), which are below the critical level.

Vector surveillance was done in hundred houses around NMPT area in the first week of November 2019 (Post monsoon) as has been done in Pre monsoon. Of the total 100 houses checked for *Aedes* breeding, 02 house premises found larval positivity (HI- 2.0%). A total of 36 water holding containers seen in the surroundings of the residential area were checked for *Aedes* breeding. Among these, 02 containers (earthen) were noted with *Aedes* larvae (CI-5.56%). The Breteau index was calculated as 2.0 (Table 2). The adult mosquitoes reared from the immature stages collected from both the seasons were identified as *Ae. albopictus*.

Table 2: *Aedes* larval indices in and around New Mangalore Sea Port.

Season (s)	No. of Premises checked	Premises positive for *Aedes* larvae	No. of containers searched	Containers positive for *Aedes* larvae	House/Premise index (HI %)	Container index (CI %)	Breteau index (BI %)
Inside the Port							
Pre monsoon	40	0	15	0	0	0	0
Post monsoon	40	02	28	12	05	42.86	30.0
Residential area							
Pre monsoon	100	01	62	01	1.0	1.61	1.0
Post monsoon	100	02	36	02	2.0	5.56	2.0

Globalization and industrialization have facilitated expanded trade and commerce. The rapid global growth and connectivity facilitates the spread of *Aedes*-borne diseases all over the world. The vast development of shipping industry and expansion of port cities during the past two centuries has led to the global spread of vector mosquitoes and pathogens related to *Aedes*-borne diseases.

A total of 40 premises were searched in the operational areas of NMPT area in the first week of May 2019 (Pre monsoon). Of the total 15 water holding containers checked, none of them found positive for *Aedes* larvae. It is obvious that in pre monsoon (comparatively dry months) maximum number of containers inside the port were dry. The nil *Aedes* positivity inside the port substantiates the dry or non-rainy climatic conditions. Entomological surveillance inside Chennai sea port [9] and Mormugao Port Trust (MPT), Goa [10] also reported a similar situation.

Similar to pre monsoon, vector surveillance was done inside the port during the post monsoon season. Of the 28 water holding containers checked, 12 (42.86%) were found positive

for *Aedes* larvae. The Breteau index was found above the critical level (Table 2). After the completion of pre monsoon vector surveillance, the investigators reported to the concerned officials that though the port area is free from *Aedes* larval breeding, the unwanted tires kept behind the Aiba-Asia should be removed to avoid *Aedes* breeding during rainy season. Of the 08 water filled tires seen in the Aiba-Asia in the post monsoon vector survey, 04 (50.0%) were found positive for *Aedes* larvae (Table 1). This indicates that any dry container seen scattered in the premises during summer months may become mosquito breeding habitats when rain water gets accumulated.

Entomological surveillance undertaken in the residential areas of NMPT area in both the seasons indicated that the *Aedes* larval indices were below the critical level. During our survey in the residential quarters of New Mangalore sea port in January 2018 [11], the team could convincingly explained to each household on the consequences of *Aedes*-borne diseases and the possible vector control measures especially source reduction activities to avoid disease outbreaks. The low level of *Aedes* larval indices noted in the present study around sea port (residential area) in both the seasons could be attributed to the high level of health awareness extended to the community in the previous visits of NCDC team.

Generally there is a marked reduction in *Aedes* mosquito breeding during dry season and a significant expansion during monsoon/post monsoon. This is mainly due to the availability of secondary foci in domestic and peri-domestic areas in rainy season which in turn facilitates the breeding of *Aedes* mosquitoes [12]. Hence the dry containers seen during dry season should be removed or kept conveniently without allowing them to fill with rain water. The dry discarded tires seen behind Aiba-Asia (inside the port) could not be removed or kept away from rain water. Hence most of the dry tires become *Aedes* breeding sources immediately after rain.

The main intention of International Health Regulations (IHR) is to maintain vector free status at seaports/airports through regular vector surveillance and vector control measures. Thus the Vector-borne disease outbreaks can be nullified or minimized in and around the ports by preventing the entry and establishment of vectors and pathogens. This would also prevent the dispersal of local vectors to distant areas through various conveyances including ships and aircrafts. Hence a careful invigilation in and around International seaports and airports by trained vector control personnel is needed to identify the factors facilitating the entry and establishment of disease vectors and implement bio-security and quarantine measures to prevent potential global health risks [13, 14].

Conclusion

Vector surveillance was carried out in and around NMPT during pre monsoon and post monsoon seasons of 2019. It has been found that Breteau index was found above the critical level in post monsoon season inside the port. However no container was found positive for *Aedes* larvae inside the port during pre monsoon survey. All the three larval indices were below the critical level in the residential areas during both the seasons. *Ae. albopictus* was the species seen in the study area. High level of Breteau index inside the port during post monsoon necessitated the need for more vigilance and further strengthening of ecology-based control measures.

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