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Entomological surveillance of *Stegomyia* mosquitoes in and around Cochin Seaport, Kerala, India

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Abstract
Mosquito-borne diseases, especially *Stegomyia* (=*Aedes*) caused virus diseases are disseminating quite rapidly and is a surging global health concern. According to International Health Regulations (IHR), a minimum of 400 meter zones around seaports, airports and ground crossings are to be maintained vector free. The present vector surveillance study was carried out in and around Cochin seaport. It has been found that larval indices *viz*., Premise index (PI) and Breteau index (BI) were above the critical level inside the port. Also, many dry containers found in the operational areas of the seaport pose potential threat as impending breeding sites of vector mosquitoes. The larval indices noted in residential areas around the seaport were below the critical level. This necessitates utmost vigilance and necessary action from the part of concerned authorities towards protecting these sensitive territories from vector mosquitoes.

Keywords: International health regulations, points of entry, Cochin seaport, *Stegomyia albopicta*

Introduction
Vector-borne diseases (VBDs) stand out to be a grave global public health issue. This also contributes to considerable economic cost in the affected countries. VBDs are endemic in most of the tropical and subtropical parts of the world, and are transmitted by hematophagous vectors such as mosquitoes, ticks, mites, sand flies and triatomine bugs. There are many factors contributing to the emergence and re-emergence of VBDs in the past many decades, including escalating population, unplanned urbanization, and increased globalization of transport and want of sufficient infrastructure [1].

VBDs constitute more than 17% of all infectious diseases and put about half of the global population at risk, causing nearly 1 million annual deaths [2].Among the mosquito-borne diseases, major threats are due to *Stegomyia*-borne viral diseases such as dengue, chikungunya, Zika and yellow fever [3]. Among the *Stegomyia* mosquitoes, *Stegomyia aegypti* (= *Aedes aegypti*) and *Stegomyia albopicta* (= *Aedes albopictus*) are known to transmit arboviral diseases among human irrespective of rural and urban divide. International Airports and Sea ports are foremost points of entry (PoE) for mosquito-borne viral infections from endemic to non-endemic countries on account of large scale influx of international travelers throughout the year.

Vast development of transport and cargo industries at International level especially during the 21st century has been attributed to global spread of *St. Aegypti* and *St. Albopicta*. Many of the countries of the Americas, European region, Western Pacific and South-East Asia were subsequently fallen under the grip of the aforesaid vectors and also most recently of Zika virus (ZIKV) [4]. The current statistics regarding vector-borne disease prevalence reveals that world over nearly 100 countries are under the threat of most of these diseases, and that significantly denotes up to 60% of the world population to be at risk [5, 6].This is in spite of the stipulations of the 58th World Health Assembly's International Health Regulation (IHR), 2005, towards maintaining strict sanitary standards at International borders and Port of Entries(PoEs) [7].Control of these vector-borne diseases across International borders continues to be an International public health matter requiring perennial attention.

India shares International ground crossings and borders with countries such as Nepal, Bhutan, Myanmar and Bangladesh. The country has resorted to significant efforts towards monitoring and implementing vector control measures [8-11].As a part of this, periodic vector surveillance and employing of guided vector control measures have been regular in and around ports of India. The present surveillance has also been part of such a programme that has been carried out in and around Cochin seaport.

2. Materials & methods

2.1 Study area

The present entomological surveillance has been carried out in and around Cochin Sea Port during third week of November 2020.It is situated in the mouth of Vembanad Lake, at 90^0 58'N latitude and $76^0$14' E longitudes (Map 1) in Kerala state, India.

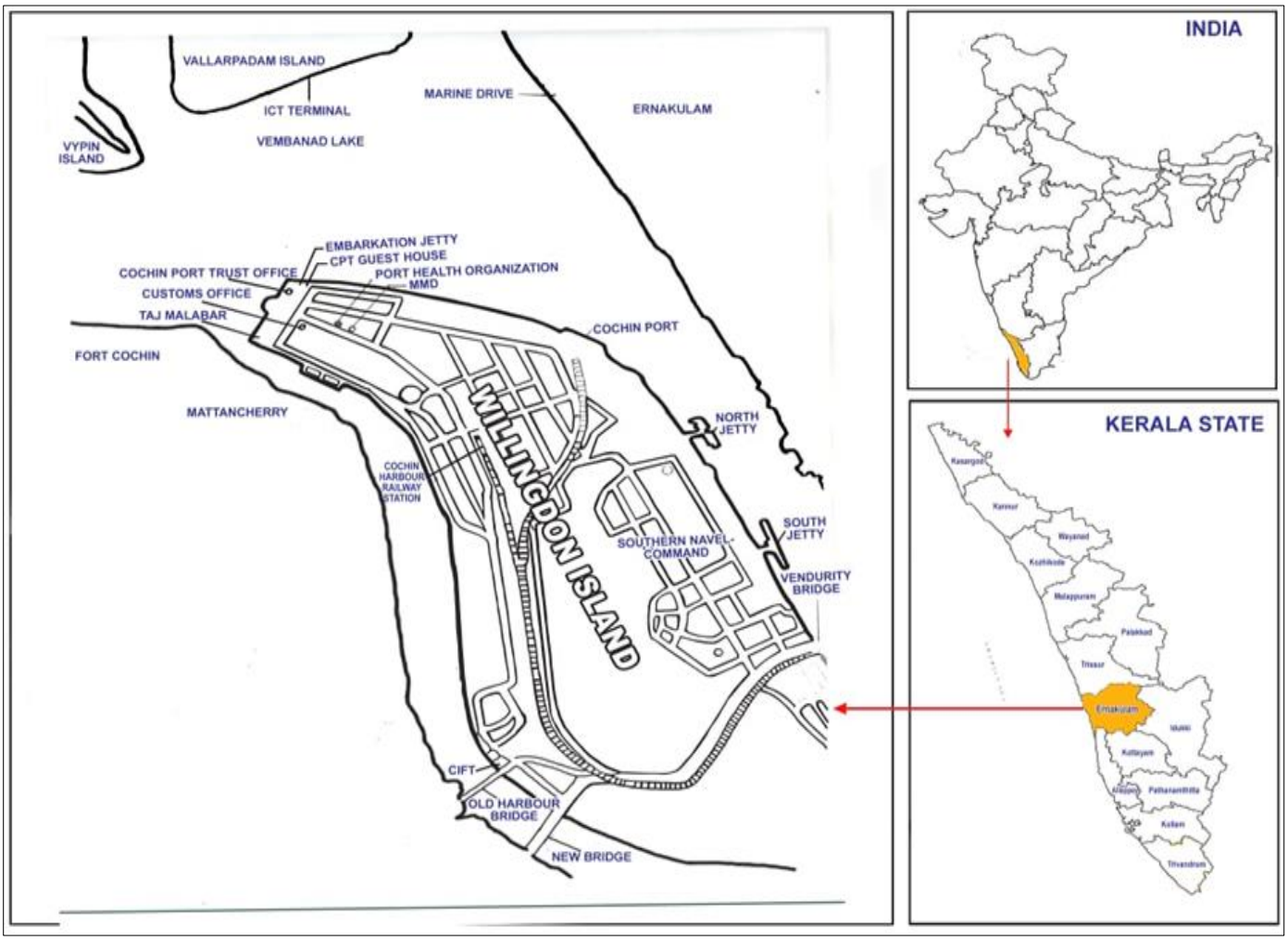

Fig 1: Showing Cochin seaport

Cochin port is an important all weather natural port in India. The port falls in the International sea route, located only 11 nautical miles from the Gulf of Singapore and also about 76 nautical miles from the Suez canal-Far East route. In addition to this, Cochin port nurture the facilities such as 1) Boat train Piper (BTP), 2) Fertilizer Berth Q10, 3) Ernakulam Wharf with 4 shedded Berths and Quay 5-9, 4) Mattancherry Wharf with 5 Shedded Berths and Quay 1-4, 5) Coal Berth having North Coal Berth and South Coal Berth and 6) Tanker Berth which contain North Tanker Berth, South Tanker Berth and Cochin Oil Terminal. Cochin seaport is one of the major seaports assigned by World Health Organization (WHO) as International Sanitary Port (ISP) in the western Coastline of the Indian subcontinent.

To assess the prevalence of vector mosquitoes around the Cochin seaport, 100 houses were randomly selected in staff quarters (Employee Quarters, CISF Quarters, Customs and Port Trust Employee Quarters) and nearby local household/building premises. Entomological surveillance has been standardized on different larval indices on the confirmation of the presence or absence of immature mosquito, especially of *Stegomyia aegypti* (Linnaeus, 1762), *Stegomyia albopicta* (Skuse, 1895), *Fredwardsius* (=*Aedes*) *vittatus* (Bigot, 1861), etc. in each container seen in and around each house/building [12].All the areas per habitat, found in and around the port were checked for the presence of immature stages of mosquitoes and recorded. Larvae/pupae from each container were collected separately. The immature stages of mosquitoes from small containers(less than 10 Liter capacity) were collected using specially designed Steiner. Larvae/pupae seen in large containers were collected using modified dipper. The larvae/pupae collected separately from each container/source were kept in separate vials that were labeled for date of collection, locality/premise, house /building number and breeding sources (container type/habitat). The vials were kept for rearing in jars filled with

150 ml fresh water and were protected with mosquito net. The larvae were fed with food (mixture of 12.5 g of tuna meal, 3.5 g of yeast and 9 g of bovine liver powder, in 100 ml of distilled water). The reared mosquitoes have been identified using standard key [13, 14].

3. Results& Discussion

3.1 Cochin seaport area

For the present study, containers from 17 premises were examined. Among these, 6 premises have been found positive for *Stegomyia* breeding (Table 1). The premise index (PI), Container index (CI) and Breteau index (BI) were 35.3%, 17.0% and 47.1 respectively (Table 2). Of the total 57 water holding containers checked, 52.63% were tires followed by metal containers (29.83%) and plastic containers (17.54%).

Table 1: Surveillance of *Stegomyia* mosquitoes in different Berths of Cochin seaport in 2020

S. No.	Berths	Type	No. of Premises searched	No. of Premises positive for *Stegomyia* larvae	No. of containers checked	No. of containers positive for *Stegomyia* larvae
1	Mattancherry (Q1 to Q4)	Dry Bulk	4	2	10	1
2	Ernakulam Wharf (Q5 &Q6)	Dry Bulk/CBFS	2	2	30	4
3	Ernakulam Wharf (Q7)	Dry Bulk/Gen	1	0	0	0
4	Ernakulam Wharf (Q8 & Q9)	Dry Bulk/Gen	2	1	12	2
5	Fertilizer Berth (Q10)	Fertilizer/ Phos Acid	1	0	0	0
6	Cochin Oil Terminal	Crude/ POL	1	0	0	0
7	BTP	Dry/ Liquid Bulk	1	0	0	0
8	North Tanker Berth	POL products	1	0	0	0
9	South Tanker Berth	POL products	1	0	0	0
10	South Coal Berth	POL products	1	1	5	1
11	North Coal Berth	Dry/ Liquid Bulk	1	0	0	0
12	Single Buoy Mooring (SBM)/ Single Point Mooring(SPM)	Crude	1	0	0	0
Total			17	6	57	8

Table 2: *Stegomyia* larval indices inside Cochin seaport in 2020

No. of Premises searche4d	Premises positive for *Stegomyia* larvae	Total water holding containers checked	Containers positive for *Stegomyia* larvae	Premise index (PI-%)	Container index (CI-%)	Breteau index (BI)
17	06	47	08	35.3	17.0	47.1

The containers found discarded in different berths of Cochin seaport were categorized primarily as dry containers and water holding containers. Each of the containers included 1) plastic, 2) metal, 3) tires. It was also found that, out of the total 2,133 dry containers examined, 2016 (99.16%) were metal containers. The rest of the containers were discarded tires and various plastic containers which constitute 15(0.71%) and 03(0.14%) respectively (Table 3).

Table 3: Details of different water holding containers noted in different Berths of Cochin seaport

S. No.	Berths	Water holding containers						Dry containers		
		Plastic		Metal		Tire		Plastic	Metal	Tire
		S	P	S	P	S	P			
1	Mattancherry Wharf (Q1 to Q4)	0	0	6	1	4	0	0	2016	0
2	Ernakulam Wharf (Q5 & Q6)	4	0	5	3	21	1	3	15	0
3	Ernakulam Wharf (Q7)	0	0	0	0	0	0	0	0	0
4	Ernakulam Wharf (Q8& Q9)	6	2	2	0	4	0	0	15	15
5	Fertilizer Berth (Q10)	0	0	0	0	0	0	0	0	0
6	Cochin Oil Terminal	0	0	0	0	0	0	0	0	0
7	BTP	0	0	0	0	0	0	0	0	0
8	North Tanker Berth	0	0	0	0	0	0	0	0	0
9	South Tanker Berth	0	0	0	0	0	0	0	0	0
10	South Coal berth	0	0	4	1	1	0	0	69	0
11	North Coal Berth	0	0	0	0	0	0	0	0	0
12	SPM/SBM	0	0	0	0	0	0	0	0	0
Total		10	2	17	5	30	1	3	2,115	15

Also, more than 2000 small to medium sized metal containers were seen scattered in Mattancherry wharf (Q1 to Q4). A total

of 117 dry containers could be found in Ernakulam wharf, of which 102(87.2%) were metal containers. Among these, most were seen scattered in South Coal Berth (67.65%). The rest of them were seen in Shed Q5 (17.64%) and in Shed Q9 (14.71%). Fifteen dry discarded tires could also be seen in shed Q9 of Ernakulam Wharf (Table 3, Fig1). The reared mosquitoes from different sources from Cochin seaport were all identified as *Stegomyia albopicta*.

Fig1: Scrap materials dumped in A) Mattancherry Wharf and B) Ernakulam Wharf

3.2 Residential area

In the residential areas, vector surveillance was carried out in 100 randomly selected houses around Cochin seaport area. A total of 15 water holding containers were examined from this area, out of which 66.67% wee plastic followed by discarded tires (26.67%) and metal containers (6.66%). Among the plastic containers, only two (0.20) were found to be positive for *Stegomyia* larvae (Table 5). The Premise index (PI), Container index (CI) and Breteau index (BI) was found to be 1.0%, 13.3% and 2.0 respectively (Table 4).

Table 4: *Stegomyia* larval indices in the residential areas of Cochin Seaport

No. of Premises searched	Premises positive for Stegomyia larvae	Total containers checked	Containers positive for Stegomyia larvae	Premise index (PI-%)	Container index CI-%)	Breteau Index (BI)
100	01	15	02	1.0	13.3	2.0

Table 5: Breeding habitats of *Stegomyia* mosquitoes in the residential around Cochin Seaport

S. No.	Type of breeding habitats	Searched	Positive for *Stegomyia* larvae
1	Plastic	10	02
2	Metal	01	0
3	Tire	04	0
Total		15	02

An analysis of the *Stegomyia* larval indices in and around Cochin seaport indicated that all the three indices, HI, CI and BI were higher inside the seaport than the residential areas around the port (Fig.2). As in the case of inside Cochin sea port, the mosquito vector identified from the residential area has also been identified to be *Stegomyia albopicta*.

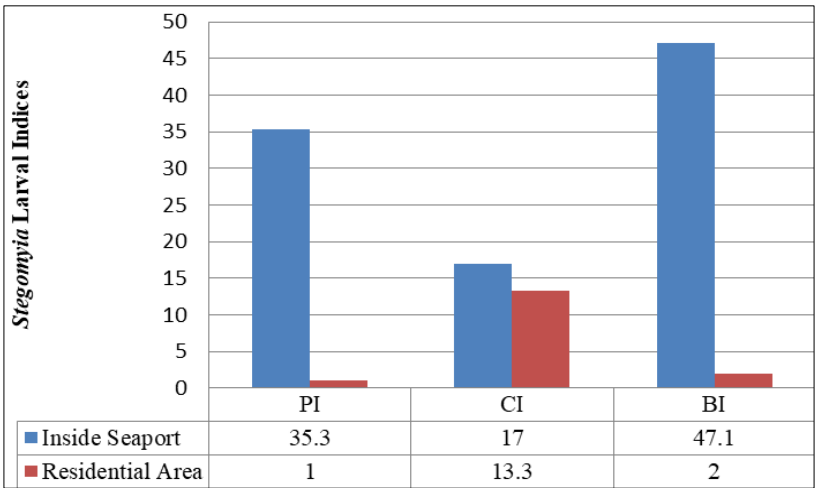

Fig 2: *Stegomyia* Larval Indices in and around Cochin Seaport

Generally, House index/Premise index (HI/PI) more than 10% and Breteau index (BI) above 20 are considered as critical. The present vector surveillance inside the pot showed that all the *Stegomyia* indices were above the critical level. It was also noted that many dry metal containers (< 2000) were seen in Matancherry Wharf (Q1 to Q4). In Addition to this, a total of 30 dry metal containers were noted from Ernakulam Wharf (Q5, Q6, Q8 & Q9). Fifteen discarded tires could also be noted in Ernakulam Wharf (Q8 & Q9). A total of 69 dry metal containers were seen scattered in South Coal Berth. As most of these dry containers were seen in open area, it is likely to get filled with rain water and become breeding sites of vector mosquitoes. So the authorities should necessarily take urgent measures to get rid of the port and premises from mosquito breeding situations.

A comparative analysis of the Premise index (PI) and Breteau index (BI) inside Cochin seaport during the last 5 years indicates that these two indices were above the critical level in all these years with a significant rise in 2017 (Fig.3). These points out that either the authorities did not heed enough to the suggestions/recommendations provided by NCDC, Kerala Branch or the measures taken were insufficient all these years. However, realizing the prevailing situations of increased threat, the authorities are expected to resort to measures so that different berths of Cochin seaport get rid of mosquito menace and consequent public health implications.

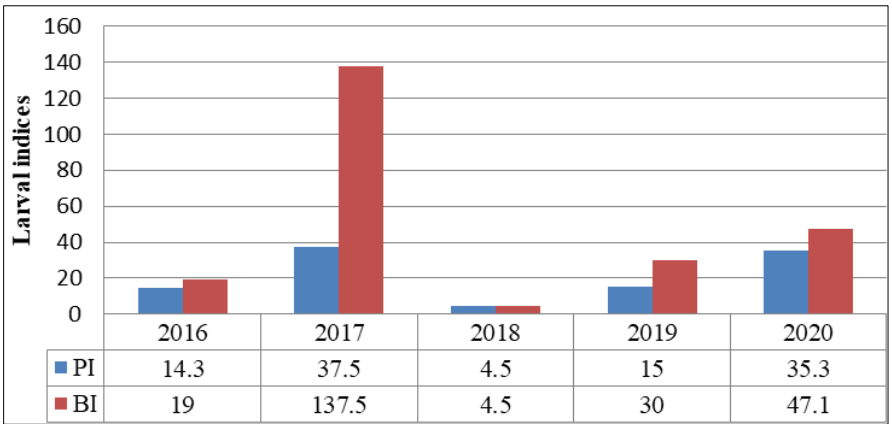

Fig3: Year-wise Premise Index (PI-%) and Breteau Index (BI) inside Cochin Seaport

At present, there are 22 international airports and 12 seaports in the country which act as PoE for the entry and establishment of vector mosquitoes. Although significant efforts are being made to address the issue of causes contributing to contact and spread of Vector-borne diseases in and around International airports and seaports, a lot remains to be done towards prevention and control of the same associated with infra-structure development, capacity building, proper monitoring and supervision at different levels. In a study on the breeding prevalence of vectors of dengue, chikungunya and yellow fever, the investigators could not find the breeding of *Stegomyia* mosquitoes inside Chennai seaport [15]. The study on the breeding habitats of vector mosquitoes in Mormugao Port Trust, Goa, also observed nil *Stegomyia* larval positivity [16]. Entomological surveillance carried out inside New Mangalore Port Trust (NMPT), Karnataka, India in 2018 also showed nil larval positivity [8]. However, Post monsoon vector surveillance in 2019 inside NMPT indicated high level of Breteau index (BI) [10]. Entomological surveillance carried out in Mumbai International Seaport in 2010 also indicated high larval indices [17]. Used automobiles tires holding rainwater were identified as key breeding sites of *Stegomyia* mosquitoes [18, 19].

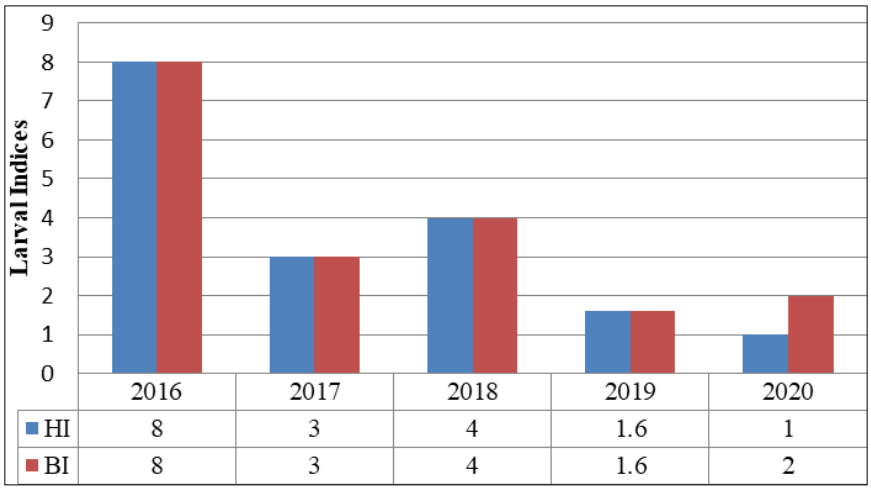

Fig 4: Year-wise House Index (HI-%) and Breateu Index (BI) around Cochin Seaport

Entomological surveillance undertaken in the residential areas around Cochin seaport during the third week of November 2020 inferred that the larval indices were below the critical level. During our earlier survey in December 2016 in the same

locality, the residents were appraised through inter-personal communication methods about the importance of adopting vector control measures, especially source reduction activities and program to prevent any disease outbreaks.. Since then, a gradual decline of larval indices (HI and BI) was noted in the subsequent vector surveillance (Fig.4). The reduced level of *Stegomyia* larval indices found in the present study (HI-1% and BI-2) around Cochin seaport indicates to increased level of health awareness among the residents imparted to them by the same investigation team during their earlier investigations.

For any disease outbreak, interaction between pathogen, host and environment necessarily play the crucial role. This is inclusive of social and demographic factors such as population growth, unplanned urbanization, and travel as also close human interactions and proximity to varied categories of disease vectors and their ideal habitats.

Port areas are exclusively expected to be maintained as vector free zones as per the guidelines of International Health Regulations (IHR). To attain this, sustained vigilance and planned control activities are to be adapted everywhere. This is very well applicable to Cochin seaport also, where an increased level of vector mosquito prevalence and activities have been found in the present study. As being the case, Cochin sea port authorities' necessarily have to resort to effective and time bound measures to bring down, if not to eliminate vector prevalence in the target area. The findings of the study avers that careful supervision in and around international seaports and airports by vector control specialists is needed to determine the factors favoring the entry and sustenance of disease vectors and implement bio-security and confinement measures to prevent international health risks.

4. Conclusion

Vector surveillance has been carried out in and around Cochin seaport during the third week of November 2020. Inside the port area, it has been found that the PI and BI were above the critical level. However, all the three larval indices were below the critical level in residential areas around the port during the same period. This is presumed to be due to high level of health awareness given to the households in the study area, in each prior visits of NCDC team. *Stegomyia albopicta* was the species seen in both inside and around Cochin seaport. High level of PI and BI noted inside different berths of Cochin seaport during the present study necessitated the need for more attention from seaport officials for strict execution of vector control measures as per IHR. Hence, Vector monitoring and recommendations of trained vector biologists is a prerequisite in planning vector management measures towards prevention of impending disease outbreaks as well as forestalling such diseases in a sustained manner.

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