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Surveillance of *Aedes* (*Stegomyia*) mosquitoes in and around International Airport, Kerala - Assessment of vector control efforts

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ABSTRACT: Vector-borne Diseases (VBDs) such as malaria, dengue, chikungunya, zika virus and yellow fever are reported in over 100 countries and put up to 60% of the world's population at risk of infection; more than 500 million cases are reported each year. The International Health Regulations (IHR) emphasizes to look after international seaports/airports and surrounding areas up to 400 meters free of *Aedes aegypti* mosquito and other vectors of epidemiological significance. Vector surveillance and control at Port of Entry (PoE) is an essential activity for the implementation of IHR. Hence Entomological surveillance was done inside and the residential areas around Cochin International Airport during 2013 to 2019. *Aedes* larval indices in both inside and residential areas outside the airport were found to be below the critical level in all these years. However the study showed no *Aedes* positivity inside the airport during 2014, 2016, 2018 and 2019. Effectiveness of vector control measures implemented in and around the airport is deliberated.

KEY WORDS: Vector-borne diseases, Port of Entry, International Health Regulations

INTRODUCTION

Vector-borne diseases are among the major cause of human sufferings in terms of morbidity and mortality, on one hand, and the stunting the social and economic growth of the country on the other. International travel and transport network play a significant role in the rapid spread of VBDs all over the world. Arboviral diseases such as Dengue fever, Chikungunya, Yellow fever and Zika virus are growing global concern due to geographic expansion of vectors and pathogens. Globalization and industrialization have opened and expanded trade and commerce, which in turn have provided impetus to increased air traffic. The rapid global growth of connectivity has been responsible for the spread of vectors and the disease (WHO, 2008; Strickman and Kittayapong, 2003; WHO, 2012). Among the invasive mosquitoes recorded all over the world, *Aedes* species are particularly frequent and grave. As several of them are potential vectors of diseases, they present significant health concerns.

Aedes mosquitoes originally found in tropical and subtropical zones carry a variety of pathogens that

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can be transmitted to humans. *Ae. aegypti* mosquito is the main vector that transmits the viruses that cause dengue, chikungunya, yellow fever and zika virus. *Ae. albopictus* is also playing the role as vector for the transmission of dengue virus as well as competent vector of 22 arboviruses, including West Nile and Yellow fever (Gubler, 2003). *Aedes* mosquito is considered a highly domesticated mosquito, very adapted to living with man, preferring to rest indoors and to feed on humans during daytime hours. The *Aedes* mosquitoes generally breed in water holding containers found in and around the houses, such as those used for water storage, flower vases, mud containers, metal containers, used tires, plastic utensils and other receptacles that collect rain water (Sheela Devi *et al*., 2012).

The incidence of VBDs proliferating rapidly due to many factors including uncontrolled urbanization that promote breeding of vector mosquitoes. World Health Organization (WHO) in 2010 stratified the current situation of DF/DHF in India under category A, which means a major public health problem, leading cause of hospitalizations and death among children. To convey the global threat due to the entry and establishment of vectors and emergence of vector-borne diseases, through point-of- entry (PoE), WHO brought Member States under a common umbrella of the International Health Regulations (IHR) in 1969 to which all the Member States were signatory. In May 2005, the 58thWorld Health Assembly adopted the new International Health Regulations (IHR), which came into force in July 2007 (WHO, 2012). At present there are 22 International airports and 12 seaports in the country, which act as PoE. In accordance with IHR, all International airports and seaports should be remain free from all types of vector mosquitoes with a range of 400 meters around the ports to achieve the ultimate aim of public health security (WHO, 2016). Thus, vector surveillance and control become a vital component for the implementation of IHR. In order to assess the effectiveness of vector control measures adopted in and around the airport, eco-entomological survey was undertaken in Cochin International Airport Limited (CIAL).

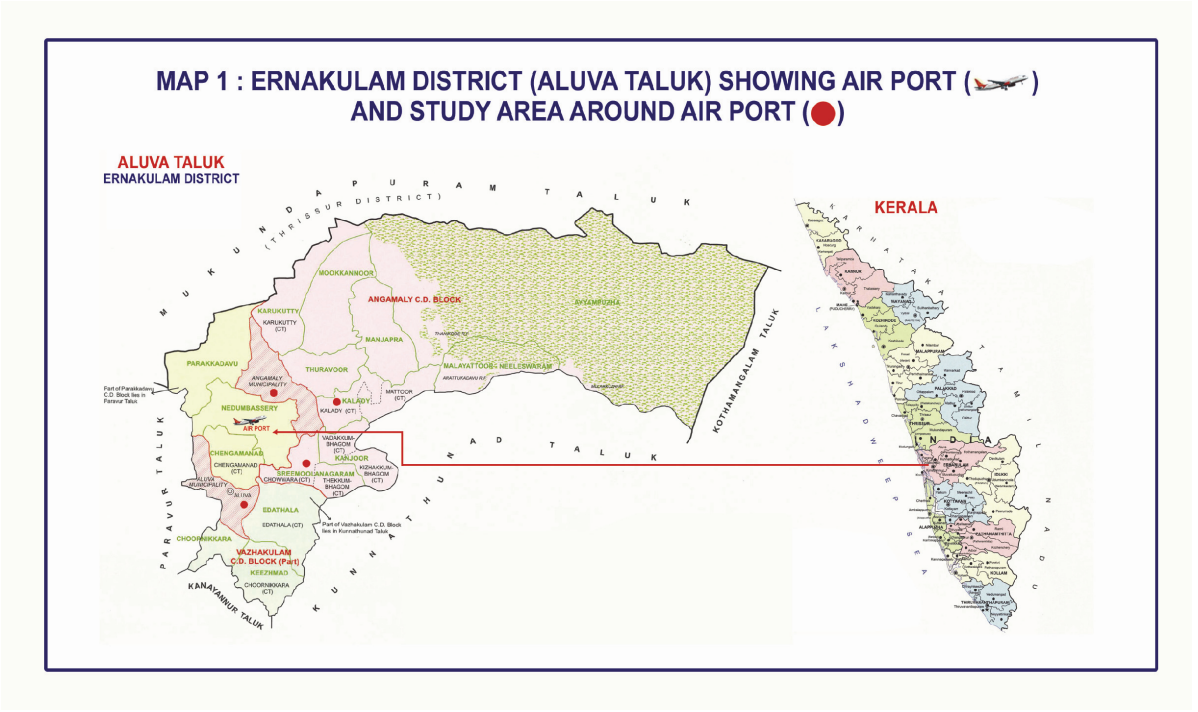
MATERIALS AND METHODS

Study area: Cochin International Airport Ltd. (CIAL) is located in Nedumbassery, about 25 Km Northeast of the city. Nedumbassery is a suburb of the city of Cochin and it lies between the two Municipalities of Aluva and Angamali in the Greater Cochin region. Nedumbassery is also an integral part of the Cochin Metropolitan area. The Entomological surveillance was undertaken in these urban and rural areas, situated around the Air port, from 2013 to 2019 (Map 1). CIAL is the largest and busiest airport in Kerala constructed under public-private partnership. As of 2019, CIAL caters to 61.8% of the total air passenger movement in Kerala. The coordinates of Cochin International airport are 10^0 091'19'' N and 76^0 23' 28'' E.

Entomological surveillance: *Aedes* survey was done in all the operational areas of Cochin International Airport and in randomly selected 100 residential houses around the airport from 2013 to 2019. In each year the survey was done in the months of November-December. Standard entomological techniques were used for survey. Larval survey was carried out in all types of water holding containers to detect the breeding of *Aedes* (*Stegomyia*) mosquitoes in and around the Airport. All accessible larval breeding habitats like discarded tires, earthen, plastic, metal containers, cement tanks, etc. were inspected. The collected larvae were identified microscopically/ after adult emergence as per guidelines (WHO, 1995).

The type of breeding habitats and their location were recorded on a predesigned proforma for classification. The data on larval survey were analyzed and calculated in terms of House index/ Premise index (HI/PI), Container index (CI), Breteau index (BI) and the preferred breeding habitats of *Aedes* mosquitoes also assessed. The dry containers seen scattered in the premises were also examined as these can act as potential breeding sources of *Aedes* mosquitoes during summer rains/ monsoon.

After the completion of the work, the report was sent to Air port health officer, Cochin International Airport (CIAL) for necessary action. The copy of

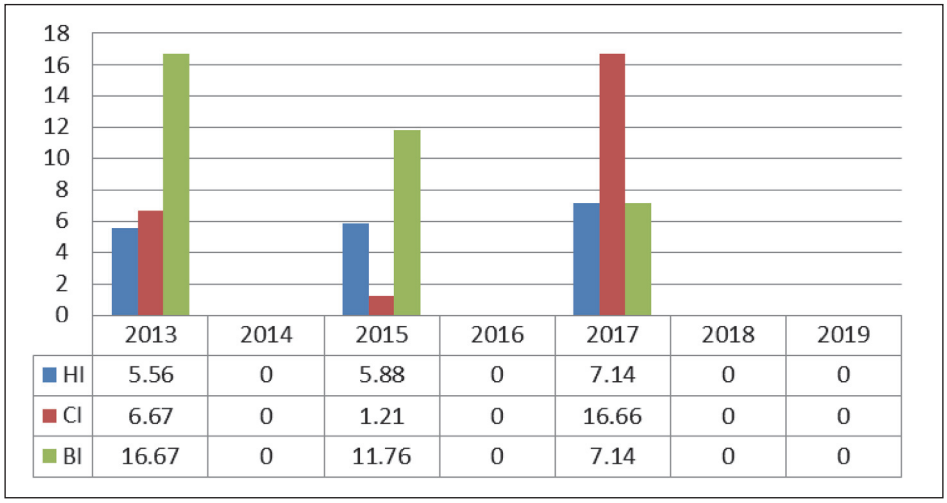


the report was sent to the Director, CIAL for follow up. The vector control activities done by the CIAL health authorities in each year on the basis of the report of NCDC, Kerala branch would be assessed by the surveillance team in the succeeding year. The observations were analyzed and assessed the progress of the activity in each year.

Residential area: Cochin Airport is located in Nedumbassery. It lies between Aluva and Angamaly Municipalities. There are nine panchayaths in Angamali C.D. Block, of which Kalady and Sreemoolanagaram panchayaths are situating adjacent to the Airport. To assess the *Aedes* mosquito prevalence around the Airport and also to assess the effectiveness of vector control measures done by the local bodies and local health system, NCDC, Kerala branch has undertaken regular vector surveillance in randomly selected wards of Angamaly Municipality (urban) and Kalady and Sreemoolanagaram Panchayaths (rural) from 2013 to 2019 (Map 1). During each Entomological surveillance, 100 houses were randomly selected from the target area and the data was analyzed statistically. After the completion of the work, the report was sent to DMO (H) of concerned district for necessary action. The copy of the report was sent to Director of Health Services, Kerala State for follow up. The vector control measures including the source reduction activities with community participation and awareness campaign done in each year based on the recommendations/suggestions of the study team would reflect in the subsequent surveillance activity. In order to assess the effectiveness of vector control measures implemented in the target area, both the qualitative (ecological conditions of the house premises, mosquitogenic and local hygiene conditions, etc.) and quantitative observations (*Aedes* larval indices and potential breeding sites of vector mosquitoes) were noted and compared with the previous observations.

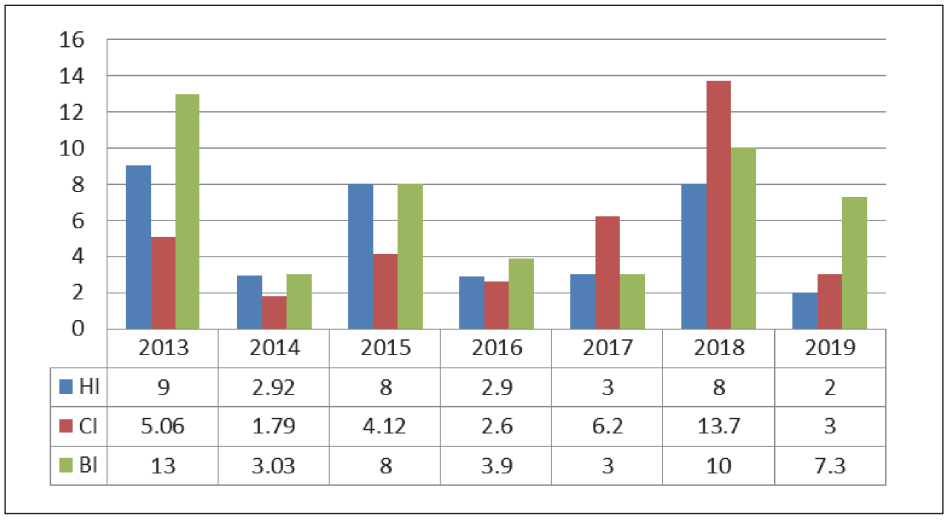
RESULTS AND DISCUSSION

Airport area: Entomological surveillance was done in CIAL during 16th and 17th of December 2013. Though a total of 45 water holding containers at 18 premises were examined, only 03 containers were found positive for *Aedes* larvae. The Premise index (PI), Container index (CI) and Breteau index (BI) were 5.56%, 6.67% and 16.67 respectively (Fig. 1). It is to be noted that the Premise index (PI) > 10% and Breteau index (BI) > 20 are considered



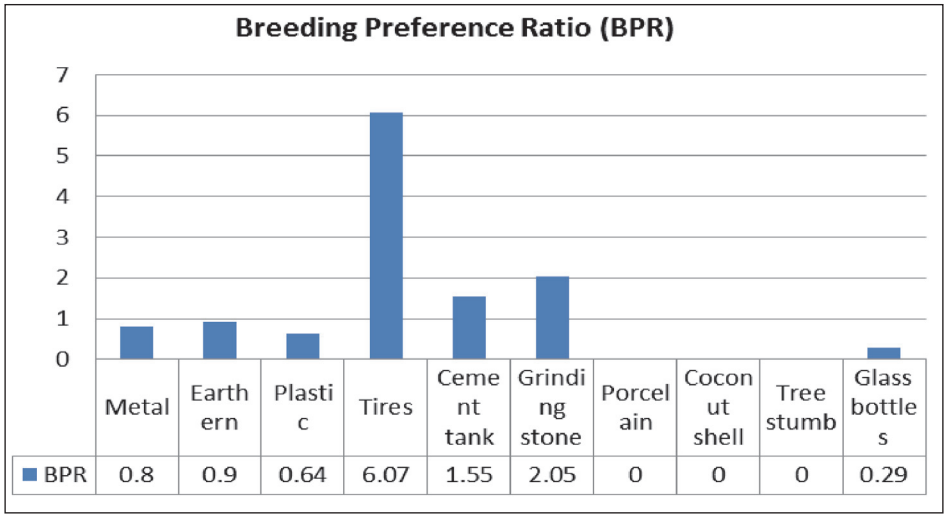
	2013	2014	2015	2016	2017	2018	2019
HI	5.56	0	5.88	0	7.14	0	0
CI	6.67	0	1.21	0	16.66	0	0
BI	16.67	0	11.76	0	7.14	0	0

Fig. 1 *Aedes* Larval Indices inside the Cochin Airport



	2013	2014	2015	2016	2017	2018	2019
HI	9	2.92	8	2.9	3	8	2
CI	5.06	1.79	4.12	2.6	6.2	13.7	3
BI	13	3.03	8	3.9	3	10	7.3

Fig. 2 *Aedes* Larval Indices around Cochin Airport



	Metal	Earthern	Plastic	Tires	Cement tank	Grinding stone	Porcelain	Coconut shell	Tree stumb	Glass bottles
BPR	0.8	0.9	0.64	6.07	1.55	2.05	0	0	0	0.29

Fig. 3 The preferred breeding habitats of *Aedes* mosquitoes around CIAL

as critical. In the present study all the *Aedes* larval indices are below the critical level. The number of *Aedes* positive containers is a decisive factor in determining the status of Breteau index (BI). Hence, if the positive containers are less, naturally the BI will also be low. Thirty nine different types of dry containers were seen scattered in the air port premise. Hence it has been suggested to intensify source reduction activities and removal or disposal of dry containers to make the premise clean and free from vector breeding sources. As part of routine Entomological surveillance in International Air ports, the survey was done in CIAL in 2014. However the study team could not found any vector breeding sources in the airport premise indicating the CIAL authority's commitment in fulfilling the responsibility. NCDC, Kerala branch did the Entomological surveillance continuously for a period of seven years i.e., from 2013 to 2019. On an average 22 premises were checked for *Aedes* breeding in the Airport in each vector surveillance. However no *Aedes* breeding could be detected in 2014, 2016, 2018 and 2019. In the other years, all the *Aedes* larval indices were below the critical level. In a study on the breeding prevalence of vectors of dengue/chikungunya and yellow fever, Sharma and Kumar (2015) could not find the breeding of *Aedes* mosquitoes inside Chennai sea port. While studying the breeding habitats of vector mosquitoes in Marmugao Port Trust (MPT), Goa, Patel *et al*. (2017) also reported a similar situation. Though 13 water holding containers at 33 premises were examined at New Mangalore Port Trust (NMPT) no containers were found positive for *Aedes* larvae (Rajendran *et al*., 2019). The CIAL authorities took much care in executing the recommendations of the study team in each year (Table 1). This is a classic example to illustrate the effectiveness of vector control measures in reducing mosquito breeding habitats in the Airport premise.

Residential area: As Entomological surveillance has done in CIAL from 2013 to 2019 and during these years, the survey has also been done in the residential areas around the Air port. In each survey 100 houses were randomly selected around the Air port to detect vector breeding sources. In 2013, the House index, Container index and Breteau index in the survey area (Angamaly Municipal area, Ward Nos. 15, 16, 17) were 9.0%, 5.06% and 13 respectively. All the *Aedes* larval indices were below the critical level. The report, in each year, was sent to DMO (H), Ernakulam and Secretary of the concerned Local Self Government (LSG) for necessary action. In every year the health department in association with LSG is implementing 'pre-monsoon drive' to clean the environment by destroying the mosquito breeding habitats. Though the larval indices are below the critical level in all the years, it never attained 'zero level' as has been witnessed inside CIAL (Fig. 2). This indicates the lack of community participation in vector control activity in the survey area. Air port premise being a closed environment and being under the control of a well secured system, effective vector control implementation is possible, if the authorities are committed. The same cannot be anticipated in an open environment where the owners are different and many. Hence it is only through regular awareness campaign the community participation could be made possible for vector control. Though number of dengue fever cases and deaths are increasing every year with the onset of monsoon, it is surprising to note that mosquito control is not yet become a felt need of the community. Though the households are creating mosquitogenic conditions in their own premises, many of the households of Kerala waiting the health workers to come and clean the environment. Dengue vector control is simple and can be achieved through regular practice of source reduction activity in our own premises. But unfortunately, the mindset of most of the inhabitants is disheartening the local health workers. Such an attitude of the community should change. People who are hailing from high literacy and health consciousness should think that it is our duty to get rid of breeding sites of mosquitoes at least from our own premises. Many investigators emphasized the importance of active involvement of community in controlling vector breeding habitats in a locality and thus to control vector-borne diseases (Sheela Devi, 2011; Rajendran *et al*., 2020).

It is observed from the present study that *Aedes albopictus* was the species seen in different habitats of the survey area. Prior to 2013, NCDC

Table 1. Details of entomological surveillance inside Cochin International Airport

Year	*Aedes* Larval Indices	Observation	Recommendation/ Suggestions	Activities done by Airport authorities	Interpretation
2013	PI-5.56% CI-6.67% BI-16.67	1. A total of 45 different water holding containers were checked, in which 03 containers were found positive for *Aedes albopictus* larvae. *Aedes aegypti* was absent. 2. 39 dry containers / utensils were seen scattered inside the airport.	1. As *Aedes* breeding was detected regular source reduction activities need to be carried out. 2. Many dry containers seen inside the airport is a potential risk factor for *Aedes* breeding during rains. Hence these containers need to be removed or disposed of safely.	Base line data	Premise index >10% and BI>20 as considered critical. All the *Aedes* larval indices are below the critical level in the present study.
2014	All the three larval indices are zero	1. Of the 20 premises searched for the presence of *Aedes* breeding, , no water holding containers were seen. However, dry containers/ utensils were seen scattered which can act as potential source for Aedes breeding during rains.	Dry containers seen scattered inside the airport need to be removed and disposed of safely.	The suggestions of NCDC, Kerala branch has been taken care by the CIAL (Cochin International Airport Limited) authorities.	Source reduction activities are perfectly done. No *Aedes* breeding sources found inside the airport
2015	PI-5.88 CI-1.21 BI-11.76	1. Out of 165 containers searched in 17 premises inside the airport area, only 02 containers found positive for *Aedes albopictus.* 2. Many dry containers/utensils were also seen scattered inside the airport area.	Timely source reduction activities should be continued to sustain the indices low.	Care has been given for source reduction activities.However efforts should be extended to locate and remove the mosquito breeding sources.	All the *Aedes* larval indices are below the critical level in the present study.
2016	All the three larval indices are zero	Out of 15 containers searched in 25 premises inside the airport, no water holding containers found for breeding of *Aedes* larvae.	Regular weekly vector surveillance and source reduction activities are to be done inside the airport.	The source reduction activities have been done as per the recommendation of NCDC, Kerala branch.	Vector control measures are perfectly done. No *Aedes* breeding sources found inside the airport

Year	*Aedes* Larval Indices	Observation	Recommendation/ Suggestions	Activities done by Airport authorities	Interpretation
2017	PI-7.14 CI-16.66 BI-7.14	1. Out of 18 water holding containers searched, 03 of them found positive for *Aedes albopictus.* 2. *A* few dry containers were found scattered inside the airport.	Timely source reduction activities should be continued to sustain the larval indices low.	Vector control measures have been done including source reduction activities.	All the *Aedes* larval indices are below the critical level in the present study.
2018	All the three larval indices are zero	A total of 22 premises have been searched for *Aedes* breeding. However none of the water holding containers was found breeding of *Aedes* mosquito.	The unwanted dry containers are to be removed and disposed of safely.	Vector control measures have been done as per the suggestion of NCDC, Kerala branch.	All the premises are comparatively clean and no mosquito breeding sources located in the area.
2019	All the three larval indices are zero	None of the water holding containers was found breeding of *Aedes* mosquito.	As dry containers are seen inside the airport premise, source reduction activities should be intensified.	Vector control measures have been done as per the suggestion of NCDC, Kerala branch.	Vector control measures are perfectly done. No *Aedes* breeding sources found inside the airport

PI-Premise Index, CI-Container Index, BI- Breteau Index

team could collect *Aedes aegypti* mosquitoes few times in and around the Cochin airport. The availability of the source/containers seen scattered in the peri-domestic environment may influence the site selection of *Aedes* mosquitoes for oviposition. The details of Entomological surveillance from 2013 to 2019 around the Air port were taken for analysis. The Breeding Preference Ratio (BPR) was calculated in order to find out the most preferred habitat selection of *Aedes* mosquitoes (Fig. 3). It has been found that around the Cochin air port, the BPR with respect to *Aedes* mosquitoes was more in Tires (6.07) followed by Grinding stone (2.05) and Cement tank (1.55). Many researchers identified the used automobile tires holding rain water as key breeding sites of *Aedes* mosquitoes (Gill et al., 2000; Sheela Devi, 2011; Sharma *et al.,* 2015; Rajendran *et al*., 2020).

Of the total dry containers/sources seen in the residential areas around Cochin Air port, 46.19% were plastic containers. During summer rain/ monsoon, the dry containers may get filled with rain water and pave for the breeding of *Aedes* mosquitoes. In order to avoid mosquito breeding, either these containers are to be removed or kept properly covered. *Aedes* breeding could be noted in the residential areas around the Air port area. The closeness of the residential area to the Air port enhances the chances of spill over of breeding of *Aedes* mosquitoes in the air port area.

Vector-borne disease control across international borders is one of the important public health issues. India is having international ground crossings and bordering districts with Nepal, Bhutan, Myanmar, and Bangladesh. The country is connected with air and water with other part of the world with entry points at airports and seaports. Transmission dynamics across borders are generally similar to Indian climatic conditions.

The risk due to the introduction of vectors, pathogens and diseases from one country to another

would be reduced if the airports and seaports were kept free of mosquito breeding, as required by International Health Regulations. A careful supervision of the airports and seaports by trained vector control personal is needed to prevent the breeding of vector mosquitoes. In most of the airports, the vector control is being done through outsourcing services. It will be appropriate if the airport health authorities can monitor the vector control activities from time to time. Regular entomological surveillance is required to identify the factors favoring the breeding of vector mosquitoes and the potential vector breeding sites. This basic knowledge is essential in formulating appropriate vector control strategy in the target area.

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