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Entomological risk factors for the high incidence of dengue in the forest fringe areas of Kerala, India

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Abstract
Incidence of dengue in Kottayam district, Kerala commences with cases reported from forest fringe areas of Kanjirappally every year. An entomological investigation was carried out to study the relative abundance of dengue vector and to delineate their breeding habitats in the forest fringe areas of Kanjirappally taluk. Four villages (Erumeli, Mundakayam, Kootikal, Koruthode) located in the forest fringe areas of Kanjirappally taluk have been selected for the study. In each study area all the breeding sources in and around 24 households covering an area of about 0.5 Sq Km were surveyed and checked for vector breeding at fortnightly intervals from February 2021 to October 2021. Immatures were collected from positive breeding site and were brought to the laboratory for emergence and species identification. Larval indices were calculated using WHO methods. *Ae albopictus* was found to be the most prevalent and widely distributed vector species and the primary vector *Ae. aegypti* was not found during the household survey. The maximum Container index and Breteau index were found to be 71.45 and 51.90 during the month of June and July which shows a linear positive correlation with rainfall and significantly higher pupal index was found during the month of May (2.96). Peridomestic water storage containers and rubber plantation associated containers were the main breeding habitat observed which accounts 64.08% and 80.29% of pupal production during the dry and wet seasons respectively. Sylvan environment of rubber plantation together with favourable climatic conditions are the key factors for the prevalence of dengue vector in the forest fringe areas of Kerala.

Keywords: dengue, *Aedes albopictus*, pupal index, rubber plantation, container breeding

1. Introduction
Dengue is caused by virus belonging to family flaviviridae and having four serotypes DENV-1, DENV-2, DENV-3 and DENV-4. Dengue infection ranged from simple fever to much more severe and sometimes fatal dengue hemorrhagic fever (DHF) and dengue shock syndrome (DSS) [1]. According to WHO about 40% of the world's population are now at risk of dengue and among all the WHO regions, the Southeast Asia and the Western Pacific regions contribute nearly 75% of the global burden of dengue [2]. *Aedes aegypti* and *Aedes albopictus* are the major vectors for dengue and dengue hemorrhagic fever. Before 1990, dengue was not widespread in India. The first case was reported in 1996 in the rural areas of Haryana state followed by several outbreaks in different parts of the country [3]. In recent years the number of dengue cases has increased tremendously all over India and almost all states are endemic for dengue [4, 5]. A study done by Oxford university on global distribution and burden of dengue estimates that India alone contribute 34% (33 million infections) of global total and 100 million asymptomatic cases occurring annually [6].
With an area of only about 1.5% of the country and about 2.8% of the population, Kerala state reported more than 13.1% of dengue cases in India for the last seven years. Dengue virus was detected in wild caught *Aedes albopictus* around Kozhikode airport of Malappuram District, Kerala [7]. Also the detection of virus from field collected adult male and female *Ae. albopictus* [8] suggest evidence for vertical transmission of dengue virus in Kerala. All four serotypes of dengue virus (DENV), DENV-1, DENV-2, DENV-3 and DENV-4, were found to be prevalent in the state [9]. For the past ten years dengue cases with varying degree of severity have been

reported from Kerala. 62307cases and 334 death reported from 2010 to 2020.Year 2017 witnessed highest number of cases (21993 cases) and death (165 death) (Fig. 1). Number of dengue cases in Kerala exhibit a clear seasonality as it reaches maximum during the southwest monsoon period (May, June and July) followed by north east monsoon season and minimum cases during the dry months of January, February and March. *Ae. albopictus* prodigiously present particularly in the Kerala's sylvan and mountainous Western Ghat ranges effectively transmitting dengue virus even in the insignificant presence of the principal vector, *Ae. Aegypti* [10].

The first case of dengue in Kerala was reported from Kanjirappally taluk, Kottayam district during 1997 and is considered as its epicenter. The taluk is bordered by Western Ghats on its east and has vast forest fringe area which recorded about 82.0% of dengue cases reported from the district. Also incidence of dengue in Kottayam district commences with cases reported from forest fringe areas of Kanjirappally every year. In view of this, the present study is undertaken to study the relative abundance of dengue vector *Ae. albopictus* and to delineate their breeding habitats in the forest fringe areas of Kanjirappally taluk.

2. Materials and Methods

2.1. Study area: Four villages (Erumeli, Mundakayam, Kootikal, Koruthode) located in the forest fringe areas of Kanjirappally taluk have been selected based on the incidence of dengue cases. The demographic status and GPS location of the study area are given in table 1. The map showing the study area are shown in Fig. 1. Total area of the taluk constitute 445.6 Km^2.Crops such as rubber, pineapple, coffee, and coco are cultivated in this region as either large scale or small scale plantations. Rubber is the major crop which covers 322.7 $Km^2$of the total area (fig. 2)

2.2. Larval survey: Entomological survey was carried out at fortnightly intervals in the four study villages from February 2021 to October 2021. In each study area all the breeding sources in and around 24 households covering an area of about 0.5 Sq. Km were surveyed and checked for vector breeding. Immatures were collected from positive breeding site and were brought to the laboratory for emergence and species identification.

2.3. Data analysis: Container index, Breateau index and pupal index were calculated as recommended by World Health Organisation (WHO). Monthly rainfall reported in the meterological station of Kanjirappally were collected from Indian Meteorological Department (IMD). Pearson's correlation was used to correlate larval indices with rainfall.

Table 1: Demographic status and GPS location of the study sites

Study village	Population	No. of households	GPS Coordinates
Erumeli	2682	652	N9.543224 E76.777473
Mundakayam	2256	528	N9.584514 E76.788834
Kootikal	1870	510	N9.575086 E76.780319
Koruthode	2874	393	N9.577739 E76.823898

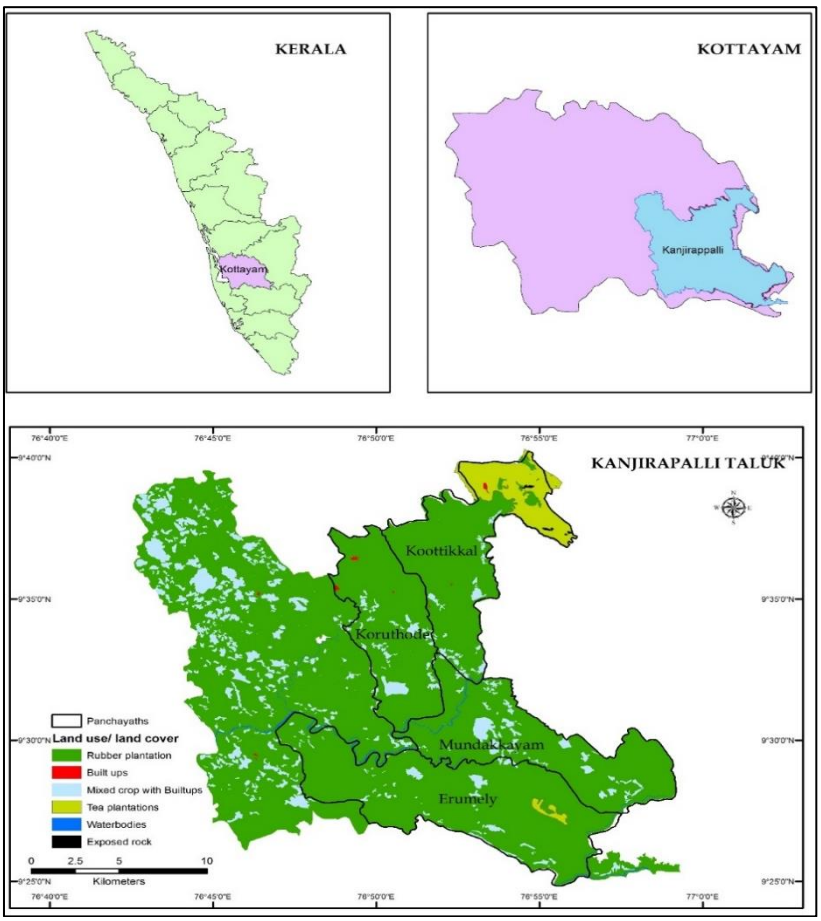


Fig 1: Map shows the different villages selected for the study from the study area (Kanjirappally taluk)

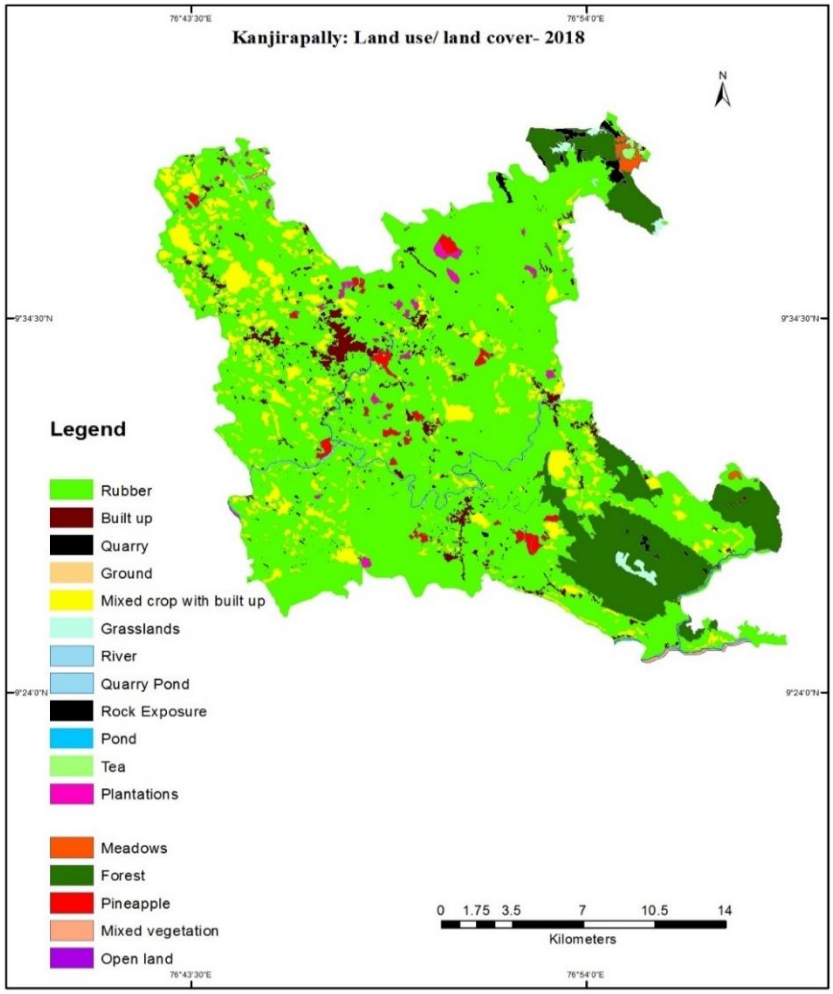


Fig 2: Map shows the different Landuse /Land cover of Kanjirappally Taluk

3. Results

The result of the study showed that among the containers 93% were found to have breeding of *Ae. albopictus*. None of the breeding site were positive for *Ae. aegypti* during the household survey. *Ae. vittatus* larvae were also found to breed in containers (5%) and non-vector species *Ar.subalbatus* were found in very less percentage (2%). It was observed that the container index and Breteau index began to increasing in May with the onset of summer rain and declined in October, end of the rainy season (Table 2). The maximum Container index and Breteau index were found to be 71.45 and 51.90 during the month of June and July which corresponds to the rainy season. One important finding in this study is that pupal index is found to be maximum during the premonsoon season from February to May reaches peak during the month of May (2.96) and gradually declined during the monsoon season. When comparing the different study villages Koruthode shows maximum CI and BI followed by Mundakayam Kootikal and Erumeli while pupal index is maximum in Kootikal followed by Erumeli, Mundakayam and Koruthode.

In Kerala, premonsoon shower start from April-May months which contribute 25-30% of rainfall while southwest and northeast monsoon contributes 70% annually. In the present study CI and BI increases with the increase of rainfall in the premonsoon (Feb-May) and monsoon seasons (June-October) (Fig. 3). From June to September southwest monsoon is active and during this period recorded highest CI and BI. When the rainfall showed a positive linear correlation with CI and BI in all the four study areas, there is negative correlation were observed between rainfall and pupal index (Table 3).

A total of 1708 containers positive for *Ae. albopictus* were collected in which 319(18.7%) were obtained during the dry season and 1408(82.4%) were obtained during the wet season from all the four study site surveyed. The main source of breeding in the peridomestic habitat were water storage containers , metal/plastic containers, discarded latex collection cups, tyres, tree holes, banana and pineapple leaf axils. Some of the breeding habitat observed in the study area are shown in fig. 4. The main source of breeding in the indoor habitat was fridge tray and flower pot tray. Peridomestic water storage containers such as plastic drums, cement tanks and cisterns were found to be the main breeding habitat (40.12%) during the dry season. Consequent to acute water shortage during the dry season, storing water have become inevitable for the community. 64.08% of breeding of *Ae. albopictus* was contributed by peridomestic water storage containers during the dry season followed by discarded containers and utensils. During the wet season, rubber plantation associated containers such as unused and discarded latex collection cup, discarded rainguards and drums or cans were the main breeding habitat (57.67%) observed which accounted for 80.29% of the total pupae collected during this season. Natural breeding habitat such as tree holes and plant leaf axils were found to be the second major breeding habitat observed during the wet season (23.22%). The massive pineapple cultivation is the ideal ground for profuse breeding

of *Ae. albopictus* during the wet season. However when comparing the pupal positivity discarded tyres constitute the second major pupal productive habitat which accounts 6.37% while leaf axils contribute only 2.97% during the wet season. A complete listing of containers infestation rate is presented in Table 3.

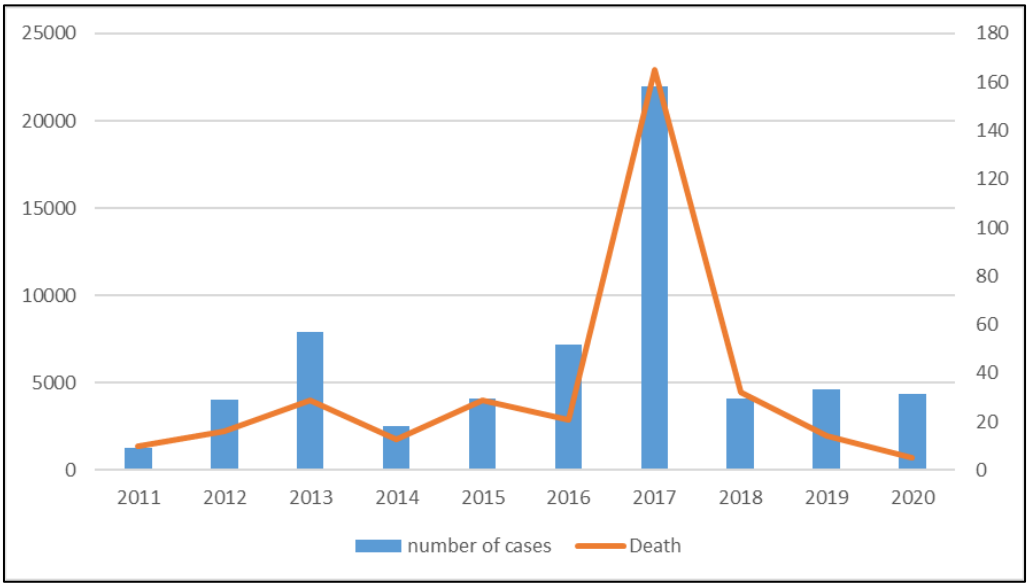
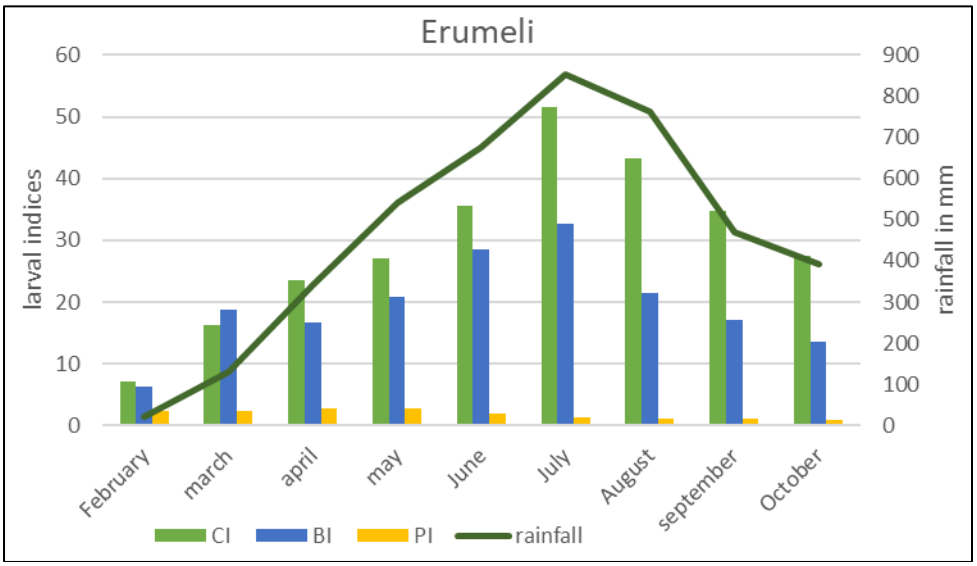


Fig 3: Year wise distribution of dengue cases and death from 2011-2020 in Kerala

Table 1: Larval indices in different study areas

Month	Erumeli			Mundakayam			Kootikal			Koruthode		
	CI	BI	PI	CI	BI	PI	CI	BI	PI	CI	BI	PI
February	7.14	6.25	2.42	5.26	2.08	2.52	4.17	4.16	2.63	10.81	8.33	1.08
March	16.36	18.75	2.32	17.39	8.33	2.20	10.82	8.37	2.52	27.03	20.83	1.27
April	23.53	16.66	2.85	16.67	18.75	2.64	27.03	12.25	2.78	16.85	12.54	1.56
May	27.03	20.83	2.74	34.87	23.84	2.43	54.85	32.56	2.96	45.64	34.61	1.67
June	35.62	28.62	1.85	64.73	46.23	1.64	50.78	38.85	1.76	71.45	45.98	0.32
July	51.50	32.61	1.32	57.92	38.90	1.51	56.53	41.75	1.29	64.74	51.90	0.15
August	43.21	21.42	1.06	39.53	21.65	1.00	43.73	25.43	1.02	52.84	49.31	0.08
September	34.71	17.13	1.13	24.72	16.43	1.33	33.24	18.93	1.09	44.95	32.17	0.31
October	27.54	13.53	1.00	14.54	9.74	1.02	15.78	8.94	1.15	27.31	15.55	0.19



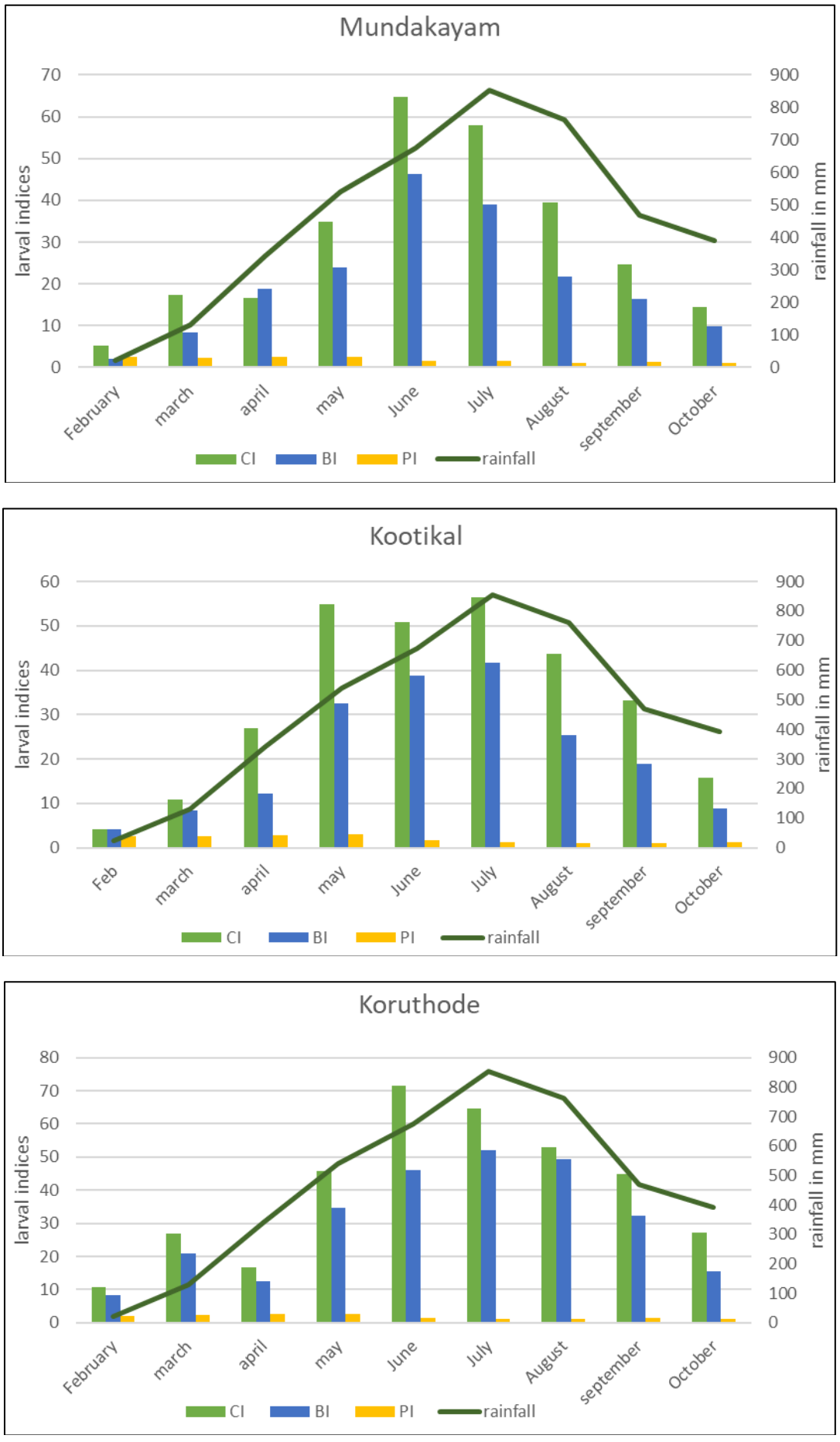


Fig 4: Larval indices in relation to rainfall in different study areas

Table 2: Correlation coefficient of larval indices with rainfall in different study area

Correlation matrix	Erumeli			Mundakayam			Kootikal			Koruthode		
	CI	BI	PI	CI	BI	PI	CI	BI	PI	CI	BI	PI
Pearson's r	0.965	0.841	-0.508	0.868	0.830	-0.580	0.888	0.918	-0.577	0.910	0.887	-0.576
p-value	< .001	0.004	0.163	0.002	0.006	0.101	0.001	< .001	0.104	< .001	0.001	0.104

Table 3: Habitat enlisted for *Ae. albopictus* breeding in different seasons

	Container type	Dry season		Wet season	
		Container positive (%)	Pupae collected (%)	Container positive	Pupae collected (%)
I.	***Peridomestic***				
1.	Water storage containers	128(40.12)	1144(64.08)	34(2.41)	54(3.51)
2.	Discarded materials:				
	Containers/utensils	94(29.4)	354(19.83)	215(15.26)	84(5.46)
	Tyre	8(2.50)	83(4.64)	15(1.06)	98(6.37)
3.	Rubber plantation associated containers	62(19.43)	148(8.29)	812(57.67)	1235(80.29)
4.	Natural breeding habitat (Tree holes/ plant axils)	9(2.82)	31(1.73)	327(23.22)	45(2.92)
II.	Domestic (Fridge tray/ flower pot)	18(5.64)	25(1.40)	5(0.35)	22(1.43)
	Total	319	1785	1408	1538

4. Discussion

Local outbreak of dengue fever which reaches an average of 540 cases annually were common in the Kanjirappally taluk of Kottayam District. Most of the cases were reporting in the rural Panchayath close to the forest fringe areas of the taluk. Greater knowledge about dengue and its transmission was associated with mosquito breeding and production [11]. Hence an entomological surveillance was initiated in the dengue reported areas of Kanjirappally taluk to find out the various factors involved in the transmission of dengue. The average rainfall is 178.7 cm and the study area is located at relatively high altitude. Larval indices were used to quantify vector breeding sites and to identify productive water container types. The present study reveals that all the vector indices were high and conducive for the transmission of the disease in all the four study villages selected. *Ae albopictus* was found to be the most prevalent and widely distributed vector species and the primary vector *Ae. aegypti* was not found during the household survey. It clearly indicate that *Ae. albopictus* is likely to be the key vector of epidemic dengue in the study area effectively transmitting dengue virus in the absence of primary vector *Ae. aegypti.* This result is similar with previous studies from other district of Kerala where this species is mentioned in a wide range of container types[12,13]. The significant presence of vegetation may be responsible for the abundance of *Ae.albopictus* in the study area since the distribution of *Ae. albopictus* is associated with vegetation throughout rural and urban areas [14].

Number of dengue cases exhibit a clear seasonality as it reaches maximum during the southwest monsoon period (May, June July). Pupal index are important to know the intensity of transmission and are considered the better and alternative indicators for adult mosquito abundance[15].In the present study significantly higher pupal index was found during the month of May. During this period temperature is very high and intermittent rainfall is characteristic of this month which favours pupal productivity [16]. Small scale rubber plantation is common and interspersed in the forest fringe areas of Kanjirappally taluk. During summer, majority of farmers suspend tapping for a period of three months (March-May). The unusable cups are found littered in the plantation area itself which also favours profuse breeding of dengue vector. Also the most efficient container in terms of breeding of Aedes was found to be the latex collection cup since the presence of latex content in the cup provide sufficient microbial load which favours oviposition and larval development. Breeding of *Aedes albopictus* in latex cups were reported in earlier studies [17]. Again peridomestic water storage containers provide ideal place for vector breeding during summer months. *Ae.albopictus* was also encountered in the leaf axils of pineapple plants which were also reported from other districts of kerala [13] and Thailand [18]. The study area has extensive pineapple plantations and breeding in plants poses a serious problem in the rainy season. All these factors contribute sporadic outbreak of dengue in the study area. In the present study CI and BI showed a positive correlation with rainfall while pupal index showed negative correlation which contrast with the findings of other studies [19, 20]. Probably, the flooding due to monsoon rain dilute the organic content of the containers, which enhances larval developmental period and retard pupal productivity.

5. Conclusion

Frequent outbreak of dengue in the forest fringe areas of Kanjirappally suggest the possible of the role of *Ae. albopictus* which were found to be prevalent in the area both in the dry and wet seasons. *Ae. albopictus* breed profusely in peridomestic containers as observed in this study. Therefore target control of this habitat or covering water storage container should reduce the risk of breeding by preventing female mosquito's access to water in which these oviposit. Proper disposal or removal of latex collection cup from rubber trees during the time when tapping has suspended reduce the chance of vector breeding. However the adaptability of *Ae. albopictus* to switch over to breeding in natural habitat such as leaf axils of pineapple plants which were found extensively in these areas poses a serious problem to control vector breeding.

Fig 5: Some of the breeding habitat observed in the study area

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7. References

1. Whitehorn J, Farrar J. Dengue. Br Med Bull. 2010;95(1):161-173.
2. WHO. Dengue Immunization, Vaccines and Biologicals. http://www.who.int/immunization/diseases/dengue/en/. Published 2019. Accessed November 29, 2021.
3. Kumar A, Sharma SK, Padbidri VS, Thakare JP, Jain DC, Datta KK. An outbreak of dengue fever in rural areas of Northern India. J Commun Dis. 2001;33(4):274-281.
4. Mutheneni SR, Morse AP, Caminade C, Upadhyayula SM. Dengue burden in India: Recent trends and importance of climatic parameters. Emerg Microbes Infect. 2017;6(8):12-15
5. Santosh Kumar PS, MCA, Gupta SK, Nongkynrih B. Malaria, dengue and chikungunya in India – An update. Indian J Med Spec. 2018;9(1):25-29.
6. Bhatt S, Gething PW, Brady OJ, *et al*. The global distribution and burden of dengue. Nature. 2013;496(7446):504-507.
7. Das BP, Kabilan L, Sharma SN, Lal S, Regu K, Saxena VK. Detection of dengue virus in wild caught *Aedes albopictus* (Skuse) around Kozhikode airport, Malappura district, Kerala, India. Dengue Bull. 2004;28:210-212.
8. Thenmozhi V, Hiriyan JG, Tewari SC, Samuel PP, Paramasivan R, Rajendran R. Natural Vertical Transmission of Dengue Virus in *Aedes albopictus* (Diptera : Culicidae) in Kerala , a Southern Indian State. Jpn J Infect Dis. 2007;60(5):245-249.
9. Pradeep Kumar N, Jayakumar PR, George K, *et al*. Genetic characterization of dengue viruses prevalent in Kerala State, India. J Med Microbiol. 2013;62(PART 4):545-552.
10. Tyagi BK, Dash AP. Dengue in India with Special Reference to the Interspecific Invasive and Virus Transmission Potential of the Asian Tiger Mosquito, *Aedes albopictus* (Skuse) in Kerala: An Update. Vector Biol. 2006, 2005:142-158.
11. Samuel PP, Thenmozhi V, Nagaraj J, Kumar TD, Tyagi BK. Dengue vectors prevalence and the related risk factors involved in the transmission of dengue in Thiruvananthapuram district, Kerala, South India. J Vector Borne Dis. 2014;51(4):313-319.
12. Bhaskar Rao B. Larval habitats of *Aedes albopictus* (Skuse) in rural areas of Calicut, Kerala, India. J Vector Borne Dis. 2010;47(3):175-177.
13. Eapen A, John RK, Dash AP. Breeding potential of Aedes albopictus (Skuse, 1895) in chikungunya affected areas of Kerala, India. Indian J Med Res. 2010;132(12):733-735.
14. Hawley WA. The biology of *Aedes albopictus*. J Am Mosq Control Assoc Suppl. 1988, 1-39.
15. Wai KT, Arunachalam N, Tana S, *et al*. Estimating dengue vector abundance in the wet and dry season: implications for targeted vector control in urban and peri-urban Asia. Pathog Glob Health. 2013;106(8):436-445.
16. Nair Deepthi G, Aravind Nisha P. Association between rainfall and the prevalence of clinical cases of dengue in Thiruvananthapuram district, India. Int J Mosq Res. 2020;7(6):46-50.
17. Sumodan PK. Potential of rubber plantations as breeding source for *Aedes albopictus* in Kerala, India. Dengue

Bull. 2003;27:197-198.
18. Preechaporn W, Jaroensutasinee M, Jaroensutasinee K. The Larval Ecology of *Aedes aegypti* and *Ae. albopictus* in Three Topographical Areas of Southern Thailand. Dengue Bull. 2006;30:204-213.
19. Oo TT, Storch V, Becker N. Factors influencing the seasonal abundance of *Aedes* (Stegomyia) *aegypti* and the control strategy of dengue and dengue haemorrhagic fever in Thanlyin Township, Yangon City, Myanmar. Trop Biomed. 2011;28(2):302-311.
20. Sharma R, Kaul S, Sokhay J. Seasonal fluctuations of dengue fever vector, *Aedes aegypti* (Diptera: Culicidae) in Delhi, India. Southeast Asian J Trop Med Public Health. 2005;36(1):186-190.