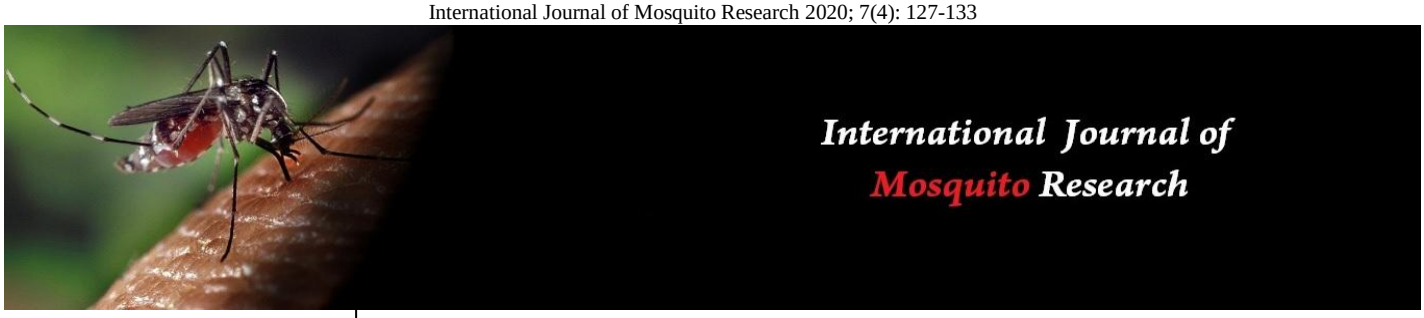

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Surveillance of the Asian tiger mosquito *Aedes albopictus* Skuse 1894 (Diptera: Culicidae) the dengue vector in rubber plantations of Kanyakumari district, Tamil Nadu, India

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Abstract
Kanyakumari district is endemic for dengue and reconnaissance of *Aedes albopictus* in relation to rubber plantations is essential. Natural vertical transmission in *Aedes albopictus* have occurred in the rural areas of Kanyakumari district, Tamil Nadu, India. In the present study, the surveillance of the dengue vector, *Aedes albopictus* in selected villages of Kalkulam taluk of Kanyakumari from June 2019 to December 2019, and its impact in the nearby villages was reported. A total of 300 houses and 772 containers in the six villages were surveyed of which 90 houses and 83 containers were tested positive for *Aedes* larval breeding. Abiotic factors, particularly rainfall assumed an indispensable role in larval breeding, other than temperature, relative humidity, and light intensity. House, Container and Breteau indices computed for the total surveyed villages were 1.88, 0.72, and 1.83 respectively. The occurrence of larval instars (I, II, III and IV) in the coconut shells of rubber plantations examined at 15 per each village were 6.30 ±0.24, 11.50 ±0.80, 14.66 ±0.52, and 7.62 ±0.38 in Anaiady; 5.30 ±0.12, 10.08 ±1.82, 15.18 ±1.50, and 6.90 ±0.14 in Kottarai; 8.68 ±0.86, 9.60 ±0.76, 12.02 ±0.98, and 5.20 ±0.60 in Manacaud; 9.20 ±0.84, 12.60 ±0.36, 14.08 ±2.16, and 6.20 ±0.34 in Pullani; 46.14 ±4.54, 20.14 ±1.88, 20.71 ±3.76, and 34.28 ±4.94 in Thiruvattar; and 8.16 ±0.65, 13.80 ±0.92, 16.25 ±1.80, and 4.80 ±0.26 in Vadakkanadu respectively. All instars upon adult emergence were identified as *Aedes albopictus* and recorded. Vector-borne diseases were reported in the study area, of which dengue was predominat. Age and sex wise distribution of people in the study area showed men and women of different age groups were affected with the most affected between 20 and 30 years followed by 10 and 20 years. The people residing in and around the rubber plantations were drastically affected by mosquito menace, and as preventive measures, coconut husks were burnt (76%). Studies on bionomics of this vector mosquito is essential, as significant presence of vegetation, particularly rubber plantations are responsible for its prevalence in the study area.

Keywords: *Aedes albopictus*, rubber plantations, abiotic factors, entomological indices

1. Introduction

Dengue, a vector-borne disease has a major impact on public health in numerous tropical nations around the world [1], and World Health Organization-South East Asia (WHO-SEA) has set India in 'Category A' [2]. Dengue is known in India since 1945 [3], and has been frequently encountered in epidemic proportions in several states [4-8], with Delhi, Punjab and Haryana in the north; Tamil Nadu, Kerala, Karnataka and Andhra Pradesh in south; West Bengal and Orissa in east; Maharashtra, Gujarat and Rajasthan in west; Assam and Arunachal Pradesh in northeast, and Madhya Pradesh in central region [8-12]. Epidemiological investigations piloted in India in 2017 disclosed more occurrence of dengue in Kerala followed by Tamil Nadu inferable from climatic conditions, and a higher demise rate in Tamil Nadu, trailed by Kerala and Uttar Pradesh [13].

The principal vector of dengue in urban areas is *Aedes aegypti*, whereas *Aedes albopictus* is the vital vector in rural areas, which indicated close relationship with people predominantly in Asian nations [14]. Corresponding to the reconnaissance of dengue cases, entomological investigations on *Aedes aegypti* and *Aedes albopictus* ought to be normally directed as they are the fundamental vectors of dengue and chikungunya in India, both in urban and rural areas [15]. Rapid expansion of *Aedes albopictus* is one reason of dengue ascend as its transformation to

lesser realized natural surroundings has become a significant obstruction in the regulation of this species and consecutively in the control of dengue [16], as its dissemination is related with vegetation all through rural and urban areas [17-19].

In southern India, dengue cases were reported during 1960's and 1970's [20, 21]. Dengue has been blasting in parts of Tamil Nadu in the previous two decades. The commonness of dengue vector and quiet dissemination of dengue infections have been distinguished in provincial and urban Tamil Nadu, which is ever expanding [22]. The problem of dengue has extended to several rural areas. Of the 38 districts in Tamil Nadu, dengue cases have been reported from 29 districts which includes outbreaks in Chennai [23], Tiruchirappalli, Krishnagiri, Dharmapuri [24], Madurai, Tirunelveli and Kanyakumari [25]. Kanyakumari district is endemic for dengue and scanty studies on *Aedes albopictus* in relation to rubber plantations have been accounted for. Natural vertical transmission in *Aedes albopictus* occurred in the rural areas of Kanyakumari, Tamil Nadu [20]. Henceforth, an endeavour has been made to study this dengue vector and its impact in chosen villages of Kalkulam taluk of Kanyakumari district, Tamil Nadu, India.

2. Materials and Methods

Kanyakumari district is the southernmost district in Tamil Nadu and mainland India, and has a varied topography with sea on three sides and the mountains of the Western Ghats flanking the northern side, and receives good rainfall from northeast and southwest monsoons [26]. The present study was conducted at the villages of Anaiady, Kottarai, Manacaud, Pullani, Thiruvattar, and Vadakkanadu situated in the Kalkulam taluk of Kanyakumari district from June 2019 to December 2019 (Figure 1). Rainfall (mm), temperature (°C), relative humidity (%) and light intensity (cd) picked as the indispensable abiotic factors were recorded in the study area. In each village, 40-60 houses were surveyed randomly for the presence of *Aedes* mosquito breeding sites during monsoon and post monsoon seasons. The number of larvae collected in each site namely house hold and containers were also recorded village wise and *Aedes* larval breeding indices were calculated. In rubber plantations, 50 coconut shells were selected in each village randomly to detect the number of *Aedes* larval instars present in each coconut shell. All larval instars were collected and brought to laboratory and species affirmed upon adult emergence according to the identification keys [27, 28]. Since the residential areas were located in and around the rubber plantations, the people affected by vector-borne diseases in the six villages were noted and classified as well. Further, the preventive measures embraced by the village residents from the mosquito menace were additionally noted.

$$\text{House Index (HI):} \quad \frac{\text{Number of houses tested positive for larvae}}{\text{Total number of houses surveyed}} \times 100$$

$$\text{Container Index (CI):} \quad \frac{\text{Number of containers tested positive for larvae}}{\text{Total number of containers surveyed}} \times 100$$

$$\text{Breteau Index (BI):} \quad \frac{\text{Total number of containers tested positive for larvae}}{\text{Total number of houses surveyed}} \times 100$$

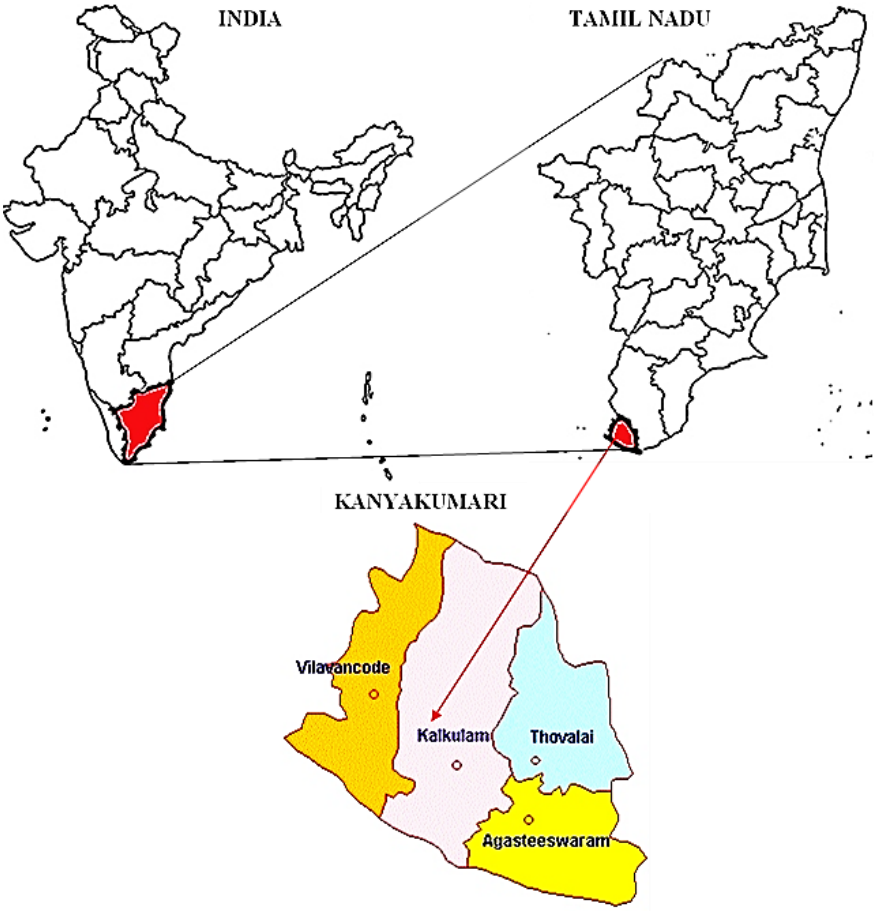


Fig 1: Map of the study area

3. Results

The abiotic factors in relation to the larval population of the study area are presented in Figure 2. A total of 300 houses in the five villages (Anaiady: 50; Kottarai 45; Manacaud: 40; Pullani: 50; Thiruvattar: 55; and Vadakkanadu: 60) were surveyed and 90 houses (9, 21, 16, 12, 18, and 14 respectively) were tested positive for *Aedes* larval breeding. Likewise, a total of 83 containers were found positive for *Aedes* larval breeding (7, 16, 13, 11, 15, and 21 respectively) out of the 772 containers surveyed. (Figure 3). House, Container and Breteau indices computed for each village, *viz*., Anaiady, Kottarai, Manacaud, Pullani, Thriuvattar, and Vadakkanadu was 0.18, 0.46, 0.40, 0.24, 0.30, and 0.40; 0.12, 0.17, 0.15, 0.14, 0.13, and 0.14; and 0.34, 0.35, 0.57, 0.22, 0.43, and 0.35, and for the total surveyed villages it was 1.98, 0.85, and 2.26 respectively (Figure 4). The occurrence of *Aedes* larval instars in the coconut shells of rubber plantations examined at 15 per each village were noted. The number of I, II, III, and IV larval instars recorded were 6.30 ±0.24, 11.50 ±0.80, 14.66 ±0.52, and 7.62 ±0.38 in Anaiady; 5.30 ±0.12, 10.08 ±1.82, 15.18 ±1.50, and 6.90 ±0.14 in Kottarai; 8.68 ±0.86, 9.60 ±0.76, 12.02 ±0.98, and 5.20 ±0.60 in Manacaud; 9.20 ±0.84, 12.60 ±0.36, 14.08 ±2.16, and 6.20 ±0.34 in Pullani; 46.14 ±4.54, 20.14 ±1.88, 20.71 ±3.76, and 34.28 ±4.94 in Thiruvattar; and 8.16 ±0.65, 13.80 ±0.92, 16.25 ±1.80, and 4.80 ±0.26 in Vadakkanadu respectively (Figure 5). Among the larval instar population, the III instar dominated, followed by II, IV and I. All larvae upon adult emergence were identified as *Aedes albopictus* and recorded. Vector-borne diseases, *viz*., dengue (26%), chikungunya (16%) and malaria (2%) were reported in the study area, of which dengue ruled the other two (Figure 6). Age and sex wise distribution of affected people in the study area recorded men and women of different age groups were affected and the most affected were between 20 and 30 years followed by 10 and 20 years (Figure 7). The people residing in and around the rubber plantations were drastically affected by the mosquito menace, and in order to protect themselves, mosquito nets, good night coils, all out liquidators, odomos cream and burning of coconut husks were utilized and practiced (Figure 8). Amongst them, the rate utilization of coconut husks burning (76%) was more accomplished, shadowed by mosquito nets (15%), good night coil (5%), and other repellents (4%) (Figure 9).

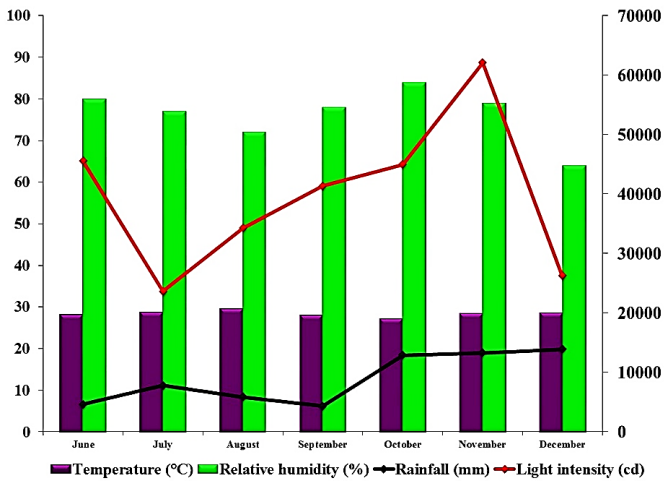


Fig 2: Abiotic parameters in the study area

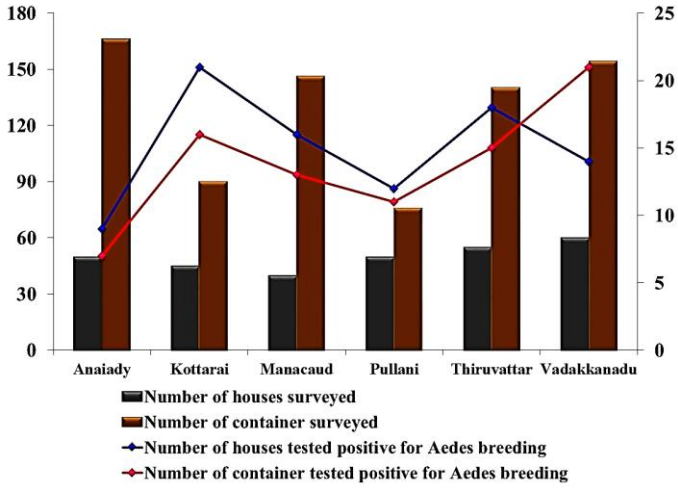


Fig 3: Survey of breeding sites in the study area

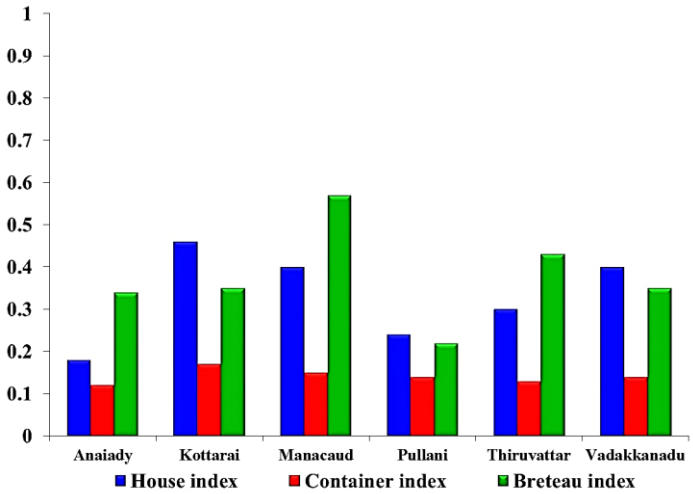
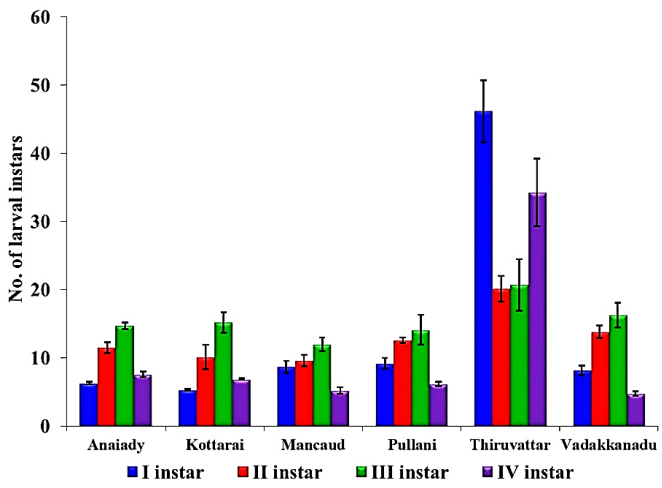


Fig 4: Larval indices in the study area



Note: Number of shells examined = 15/village

Fig 5: Occurrence of larval instars of *Aedes albopictus* in coconut shells of rubber plantations

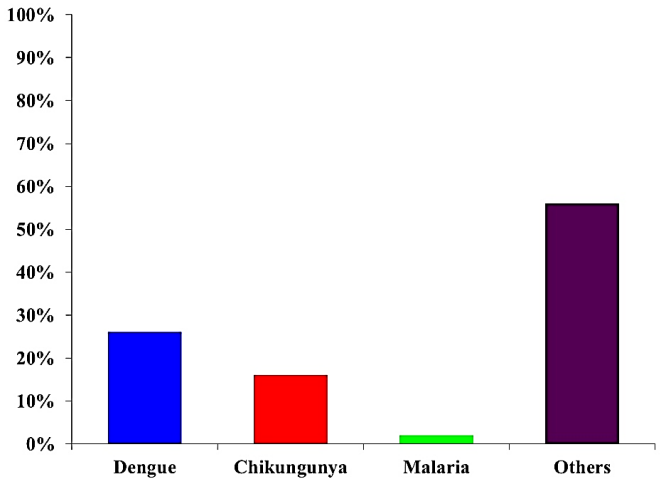


Fig 6: Incidences of vector-borne diseases in the study area

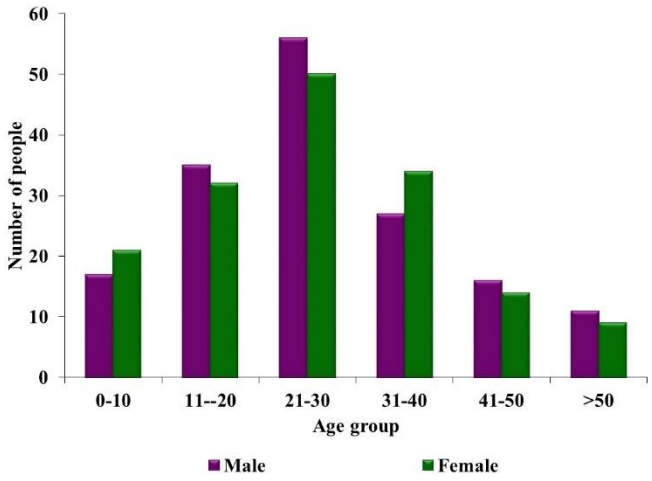


Fig 7: Age and sex wise distribution of people affected by dengue in the study area

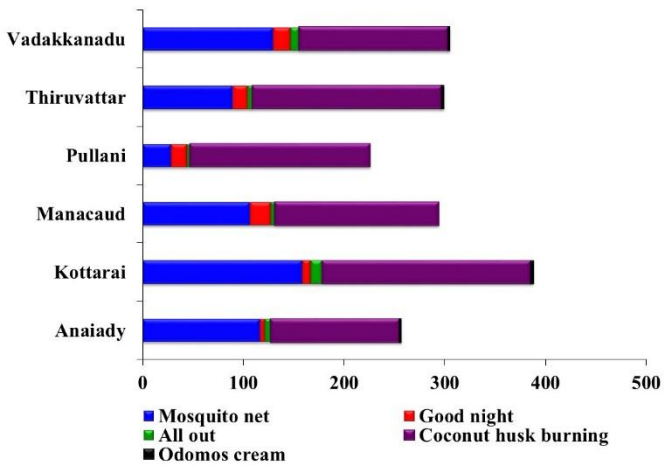


Fig 8: Preventive measures adopted against vector-borne diseases by the villagers in the study area

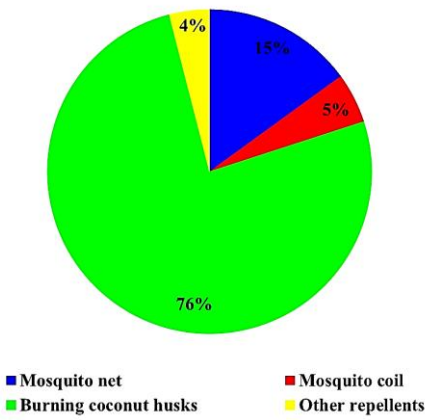


Fig 9: Percentage of preventive measures adopted by the villagers in the study area

4. Discussion

Aedes aegypti is the primary vector of dengue, but later it was also indicated that *Aedes albopictus* was also the vector liable for transmission of dengue in several other Asian region such as in India, Indonesia, Thailand and Malaysia [29-31]. *Aedes albopictus* may adapt very well to human habitation and can be more abundant than *Aedes aegypti* in certain areas, and current dengue vector control approaches are more focused on the indoor breeding mosquitoes rather than the outdoor breeder [31]. *Aedes albopictus* is a rural outdoor species, however recently, it was reported that the species is adapted to urban and suburban areas which overlaps with the distribution of *Aedes aegypti* with single or mixed infestation in the same breeding container [32-34]. It prefers vegetated areas and breeds in artificial and a variety of natural water containers [18, 35]. This vector is primarily a forest-fringe mosquito, breeding in natural sites including rock pools, leaf axils, tree holes, cut bamboo stumps, etc., and widespread increase in plantations especially of rubber, cocoa and areca nut have certainly contributed to its rapid spread with extensive breeding in containers used for collecting rubber sap in rubber plantations during the rainy season [36,37]. In addition, this vector species dominated sites related to tree density as it is most likely related to the presence of oviposition sites, as undisturbed forest with suitable oviposition habitat served as an ideal source for its breeding [38].

Mosquitoes are sensitive to changes in environmental conditions such as shade, temperature, humidity, and rubber plantations provide a suitable habitat than the rainforests for their profuse breeding [39]. These conditions are regularly impacted by changes in land use. In addition to providing economic benefits for the population, rubber plantations provide suitable habitats for the mosquitoes, and new plantations lead to increased mosquito density and disease incidence. Thus planting large tracts of rubber potentially increase the likelihood of the re-emergence of vector-borne diseases [40]. Rubber plantations in Kanyakumari district serves as an ideal breeding source for *Aedes albopictus* as they play a vital role in transmission of vector-borne diseases, particularly dengue [41]. The present study too recorded incidences of vector-borne diseases during the study period with dengue domination followed by chikungunya and malaria. Forest dwelling mosquitoes require a shaded environment for its survival and reproduction. Large areas of rubber plantation tend to offer dense vegetation and therefore high humidity and shade provide suitable environmental conditions for the larval habitats even during dry season.

Vector surveys indicated that *Aedes albopictus* breeds in the containers of coconut shells used for collecting rubber sap while tapping [14, 37], since rubber plantations serve as vital breeding sources for their proliferation [36, 42, 43]. Rubber plantations practices favoured the abundance of *Aedes* breeding sources and *Aedes albopictus* was found to be the predominant species [44]. The immature breeding habitats of *Aedes albopictus* include the rain water collections in the innumerable discarded and fixed but unused rubber latex collection containers, tree holes, leaf axils, and fallen leaves of rubber plantations [36, 45]. The prolific development of *Aedes albopictus* in latex-collecting containers attached to rubber tree-trunks in rubber plantations has been proposed to have offered ascend to the intermittent pestilences in Kerala [46,47]. In Tamil Nadu too, *Aedes albopictus* breeding in rubber collection cups where rainwater stagnates was found to be higher at Moopuvilai (79.1), followed by Pacode (58.6) and Venganamkode (52.2) villages of Kanyakumari district [48].

The population dynamics of *Aedes albopictus* larval population in the study area with reference to the rubber plantations were governed by the abiotic factors. The present study recorded all larval instar phases of *Aedes albopictus* in the coconut shells used to collect latex from the rubber trees. From the high larval population, it was apparent that hydrological parameters governed the immature population levels of *Aedes albopictus*. Tamil Nadu gets downpours in four spells: winter (January-February), pre-monsoon (March-May), monsoon (June-September) and post-monsoon (October-December). The northeast monsoon, starting in October and lasting up to December, is marked with heavy rainfall, whereas the southwest monsoon, from June to September, accounts for moderate rainfall. Rainfall is scanty in the premonsoon period. Of the total annual rainfall in the state, 48% is received during the northeast monsoon, 32% during the southwest monsoon and the rest during other seasons [49]. Kanyakumari receives rainfall from northeast and southwest monsoons, thereby making climate and other abiotic factors in particular rainfall specifically perfect for the breeding of *Aedes albopictus* which has been affirmed in the present study. During southwest monsoon season, rubber plantations have been found to be transformed into an ideal ecosystem for the proliferation of mosquitoes [36]. This associates to the report of *Aedes* survey in Kerala which had shown the presence of *Aedes albopictus* in rubber plantation areas [11]. During the period of present study, rainfall was overwhelming during the northeast and southwest monsoon which loan the suspension of latex tapping, thereby contributing to profuse breeding of *Aedes albopictus*. Thus, larval density was found to be directly proportional to rainfall. In addition to rainfall, temperature, relative humidity, and light intensity likewise assumed a role in the proliferation of this vector species.

Entomological indices are significant markers to know conceivable flare-up of dengue. House Index and Container Index are vital determinants of extent of breeding and intensity of mosquito breeding respectively. House Index has been widely used to monitor the infestation levels, whereas, Container Index provides the valuable information on the proportion of water holding containers that are infested. Equally, Breateau Index is more applicable, as it correlates the positive containers and houses inspected and thus is regarded as an excellent risk indicator of dengue outbreaks [50]. The House, Container, and Breateau indices in the present study were 1.88, 0.72, and 1.83 respectively. Despite the fact that these qualities are seen as lower than ordinarily satisfactory cut-off points, it can't be messed with and dismissed, since there are cases where dengue transmission happened in any event, when House index was <2% in Singapore [17]. Therefore, these commonly used larval indices are valuable for deciding general conveyance, seasonal changes and principal larval habitats, as well as for evaluating the environmental sanitation programmes and have direct pertinence to the elements of malady transmission. However, the threshold levels of vector infestation that constitute a trigger for dengue transmission are influenced by many factors, including mosquito longevity and immunological status of the human population.

When compared with *Aedes aegypti* which are endophilic and endophagous, sensitive biters; *Aedes albopictus* rests and feeds outdoors (exophilic and exophagous). They feed aggressively and opportunistically during the day on a wide range of hosts dependent on their availability and the environment [51-53]. This species prefers humans (anthropophilic behaviour), but also can feed on a large variety of animals (zoophilic behaviour) [35, 51, 53]. The opportunistic zoophily enhances the spectrum of pathogens it can vector and the ecological niches it can occupy [35]. *Aedes albopictus* lay eggs within 1km from the site of a blood meal [54, 55], and human settlements in and around rubber plantation are defenceless to vector-borne diseases [56]. Generally rubber plantation play a significant role in the economy of the region and also increase contact of human population with *Aedes albopictus* that secures more noteworthy epidemiological significance. Therefore in order to short circuit the transmission of dengue by this vector mosquito, application of rock salt into the coconut shells used for latex collection should be practiced, because during rains, salts dissolve make the water content inside the coconut shell salty, thereby preventing breeding of mosquitoes. Also, the level of community participation in the anti-mosquito operation in the study area has been found to be minimal due to the lack of awareness in the community regarding the breeding pattern of vector mosquitoes and spread of vector-borne diseases. *Aedes albopictus*, being exceptionally versatile, intrusive and adaptable in its conduct, adequately communicates dengue infection virus even in the absence or insignificant presence of principal vector *Aedes aegypti*, alluding towards its primary, rather than secondary role in the disease transmission. Thus studies on the bionomics of this vector mosquito is vital, since it is gradually uprooting *Aedes aegypti* from its natural surroundings and habitats [57, 58], and significant presence of vegetation, especially rubber plantations may be responsible for the commonness of *Aedes albopictus* in the study area.

5. Conclusion

Dengue continues to spread to new rural areas and populations in increasing magnitude, and surveillance programmes capable of detecting rise in vector outbreaks or disease emergence well in time are crucial. This study featured the significance of dependable information for a potential flare-up of dengue. Further point by point studies could uncover the relations of climatic, ecological and human-actuated components answerable for dengue episodes, which would help in developing procedures to manage likely flare-ups well ahead of time.

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