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Mosquito fauna in the urban and rural areas of rubber plantation sectors of Kerala

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Abstract
Among arthropod vectors, mosquitoes are the most important vector that transmit diseases such as Malaria, Filariasis, Chikungunya (CG), Dengue Fever (DF), Yellow Fever, Japanese Encephalitis (JE) etc. Forest fringe associated rubber plantation areas are more prone to the spread of zoonotic diseases to rural and urban areas. In view of this, a study was conducted to assess the species composition and density of mosquitoes in the urban and rural areas of rubber plantation sectors of Kottayam district. Two villages from forest fringe associated rubber plantation areas and two wards from urban areas of Kottayam district were selected for the study. Immature and adult mosquitoes were collected based on WHO standard procedures. A total of 14 mosquito species were recorded in the present study in which five species belong to the Aedeine group. *Aedes albopictus* was the predominant vector species in the study areas. *Aedes albopictus* was found to be abundant in the urban areas while *Armigeres subalbatus* was recorded as the prevalent species in the rural areas. Per man hour density of mosquitoes were found maximum during June and July and density of *Aedes albopictus* found maximum during the month of May. Water storage containers were observed to be the major breeding habitat for *Ae. albopictus* in urban areas and discarded or unused rubber latex collection containers were found to be the main breeding source for *Ae albopictus* in rural areas. Since *Aedes* transmitted diseases such as dengue and chikungunya are being reported in the study area entomological surveillance and its significance can be used to halt the outbreak as shown in this study.

Keywords: Rubber plantations, vector mosquitoes, *Ae albopictus*, dengue, chikungunya

1. Introduction
Among arthropod vectors, mosquitoes are the most important vector that transmit diseases such as Malaria, Filariasis, Chikungunya (CG), Dengue Fever (DF), Yellow Fever, Japanese Encephalitis (JE) etc. Rubber plantations are very much similar to manmade forests with lower temperatures and higher humidity under the canopy which provide suitable conditions for the mosquito vectors of dengue, chikungunya, malaria etc. Kerala state has the largest rubber plantations in the country to the tune of about 5.45 lakh ha. In Kerala, the forest fringe associated rubber plantations are located at the foothills of Western Ghats on the western coast of India. Forest fringe areas and associated rubber plantations are more prone to zoonotic diseases from where it spread to rural and urban areas [1]. During 2007 Chikungunya outbreak in India, 55.8% of suspected cases were reported from Kerala and was the worst affected state in the country [2]. In Kerala, Kottayam and Pathanamthitta were the worst affected districts contributing 44.33% and 14.37% of the total CHIKV cases, respectively [2]. Also dengue fever cases has shown an increasing trend in Kerala since 2006. More than 13.1% of dengue cases were reported from Kerala during the dengue outbreak happened in India during the year 2017. All the four serotypes of dengue virus (DENV-1, DENV-2, DENV-3 and DENV-4) were reported in Kerala [3]. The first case of dengue in Kerala was reported during 1997 from the forest fringe areas of Kottayam District [4] and continues to contribute the maximum number of dengue cases next to Trivandrum District in the state every year.
Topographically, Kottayam district has abundant rubber plantations (109, 582 ha) which support profuse breeding of *Aedes albopictus*, the main vector of Dengue and Chikungunya infection. Rainwater that accumulates in the latex collection containers during the monsoon season are the major breeding habitat of this species [2, 4].

Massive deforestation, development of human settlements es are the important human activity related to the sprealong forest fringe areas, transportation through different modad of this vector species in Kerala [5]. As the cases of mosquito borne diseases are being reported frequently in Kottayam district a preliminary survey was carried out to understand the species composition and prevalence rate of mosquitoes in the urban and rural areas of Kottayam district.

2. Materials and Methods

Two villages in the forest fringe associated rubber plantation areas, Kootikal and Koruthode of Kanjirappally taluk and towards in urban areas, Pallom (ward 13) and Puthuppally (ward 22) of Kottayam district were selected (Fig. 1). Fortnightly survey were carried out in the 4 areas from May 2021 to November 2021. Larvae were collected using WHO standard methods. Outdoor resting mosquitoes were collected using sweep nets on man hour basis [6]. For larval survey all breeding sources or sites in and around 10 households covering an area of about 0.5Sq.Km were enlisted and checked for vector breeding both in urban and rural areas. Immatures collected from the positive sites were kept for emergence in the laboratory and emerged species were identified using Keys [7, 8].

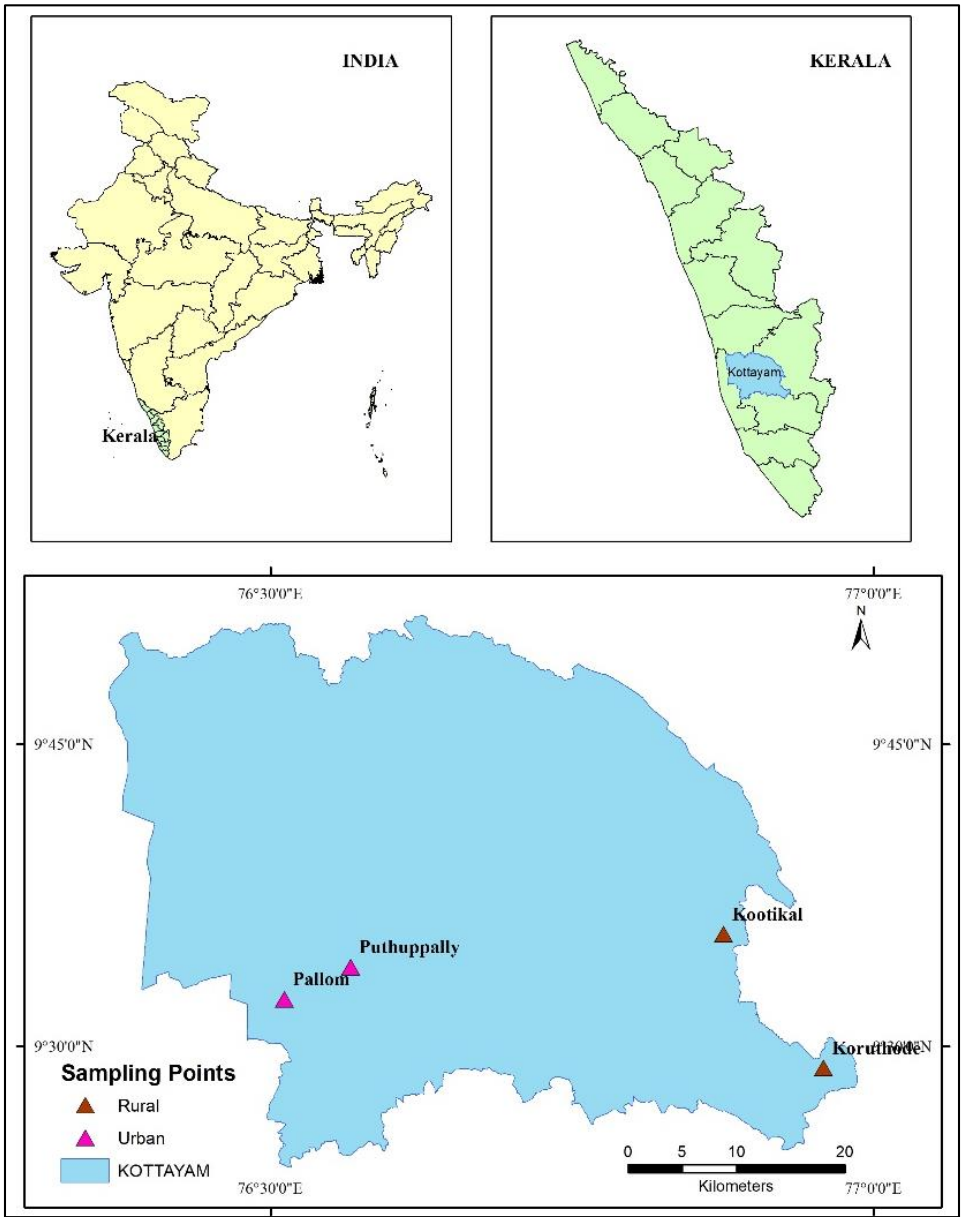

Fig 1: Study area showing sampling stations

3. Results

In the present study a total of 14 species of mosquitoes were recorded in the urban and rural areas of Kottayam district (Table 1). Five species belong to the genus *Aedes* have been recorded. *Aedes albopictus*, the secondary vector of dengue virus were found to be abundant in both urban and rural areas. Other non-vector species recorded under *Aedes* include *Aedes crysolineatus*, *Aedes vittatus*, *Aedes pseudotaeniatus* and *Aedes cogilli*. Under the genus *Culex* 3 species were recorded *Culex uniformis*, *Culex quinquefasciatus* and *Culex gelidus*. *Anopheles stephensi* and *Anopheles subpictus* are the species recorded under genus A*nopheles*. Non vector species such as *Armigeres subalbatus*, *Toxorhynchites splendens*, *Heizmannia discrepens* were also collected from the study sites.

Table 1: Species composition and prevalence rate of mosquitoes in the study areas

SL No	Species	Kootikal (Rural)		Koruthode (Rural)		Pallom (Urban)		Puthuppally (Urban)	
		N	%	N	%	N	%	N	%
1	*Aedes albopictus*	443	27.6	565	36.0	791	80.5	983	78.50
2	*Aedes chrysolineatus*	259	16.1	212	13.51	5	0.5	23	1.84
3	*Aedes vittatus*	0	0	4	0.25	3	0.3	21	1.67
4	*Aedes cogilli*	3	0.2	11	0.70	0	0	1	0.1
5	*Aedes pseudotaeniatus*	7	0.43	3	0.20	0	0	0	0
6	*Culex uniformis*	195	12.1	183	11.7	13	1.32	50	4.0
7	*Culex gelidus*	8	0.46	0	0	0	0	2	0.12
8	*Culex quinquefasciatus*	2	0.12	0	0	4	0.4	5	0.40
9	*Anopheles subpictus*	0	0	0	0	1	0.1	3	0.24
10	*Anopheles stephensi*	0	0	0	0	0	0	2	0.12
11	*Heizmannia discrepens*	0	0	3	0.2	0	0	1	0.1
12	*Mansonia uniformis*	0	0	0	0	1	0.1	1	0.1
13	*Toxorhynchites splendens*	2	0.12	2	0.12	0	0	1	0.1
14	*Armigeres subalbatus*	686	42.8	587	37.4	165	16.8	160	12.8
	Total	1605	100	1570	100	983	100	1253	100

N = Number of mosquitoes collected

Most prevalent species in both urban and rural area was *Aedes albopictus* and *Armigeres subalbatus*. Other species recorded were not much prevalent in both areas. In the rural areas of Kootikal and Koruthode, the most prevalent species recorded was *Armigeres subalbatus* (37.4% to 42.8%) followed by *Aedes albopictus* (27.6% to 36.0%), *Ae. crysolineatus* (13.51% to 16.1%) and *Cx. uniformis* (11.7% to 12. 1%) (Fig 2 and 3). In the urban areas of Pallom and puthuppally the most prevalent species recorded was *Aedes albopictus* (78.50% to 80.5%) followed by *Armigeres subalbatus* (12.8% to 16.8%), *Culex uniformis* (1.32% to 4.0%) and so on (Fig. 4 and 5).

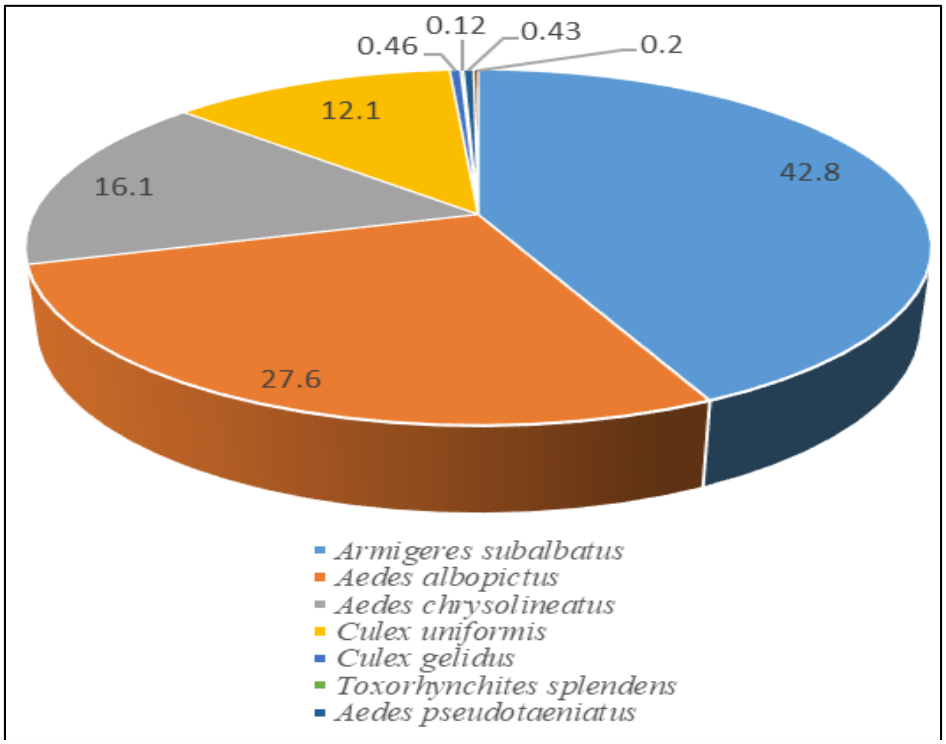

Fig 2: Species composition of mosquitoes in rural areas of Kootikal

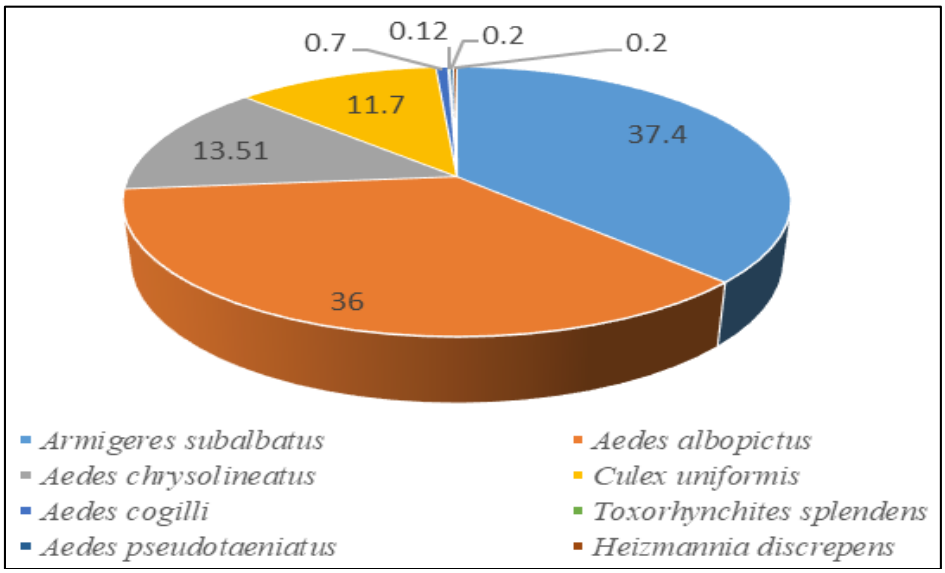

Fig 3: Species composition of mosquitoes in rural areas of Koruthode

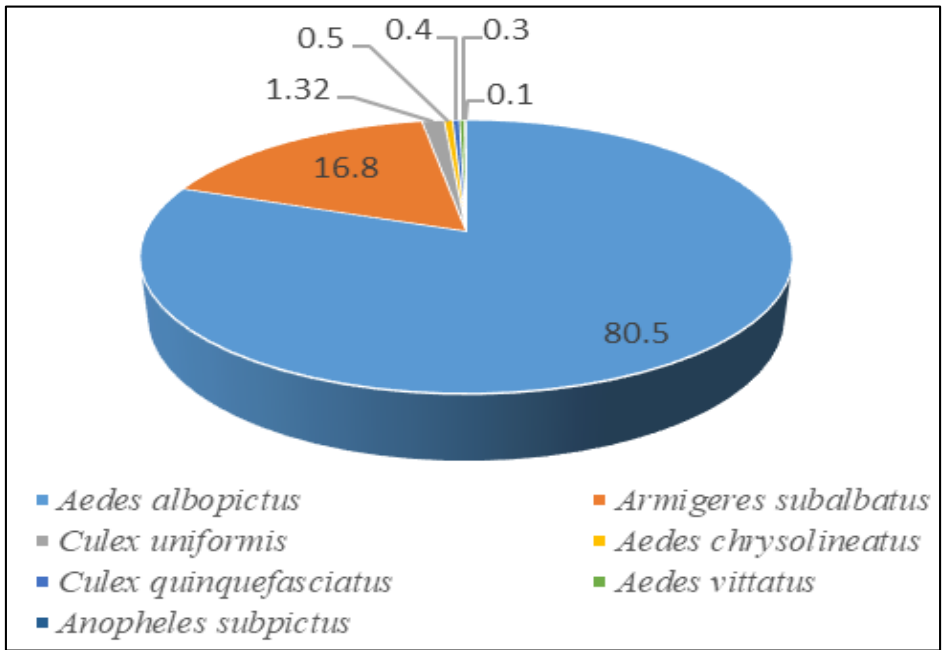

Fig 4: Species composition of mosquitoes in urban areas of Pallom

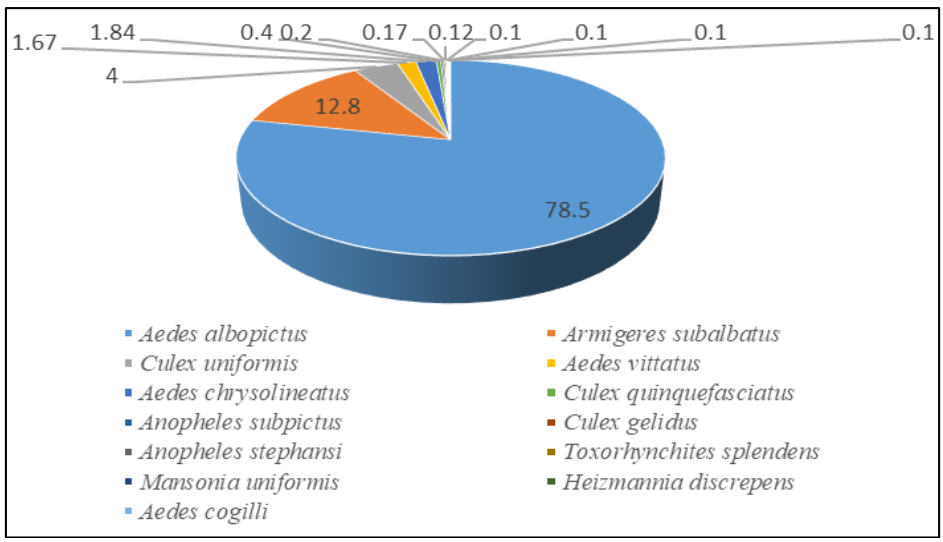

Fig 5: Species composition of mosquitoes in urban areas of Puthuppally

Man hour density of total mosquitoes vary in different months both in rural and urban areas (Fig. 6 and 7). However there is no significant difference observed in the per man hour density of mosquitoes between rural and urban areas (t=1.43, p = 0.178). When comparing different months total mosquito density was found to be high during the month of June and July while density of *Aedes albopictus* was found to be high during the month of May both in urban areas and rural areas. Also man hour density of *Ae Albopictus* was found to be high in urban areas compared to rural areas.

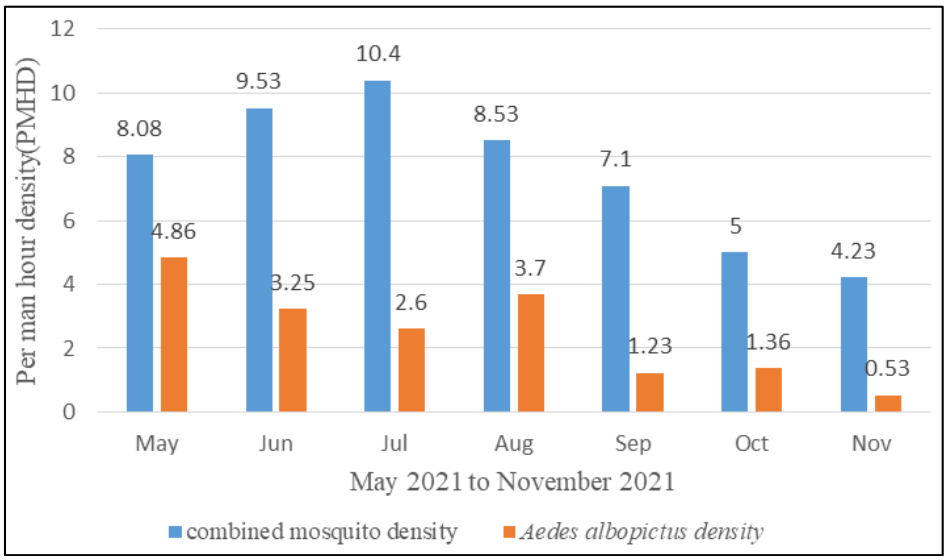

Fig 6: Per man hour density of mosquitoes in the rural areas of Kottayam district

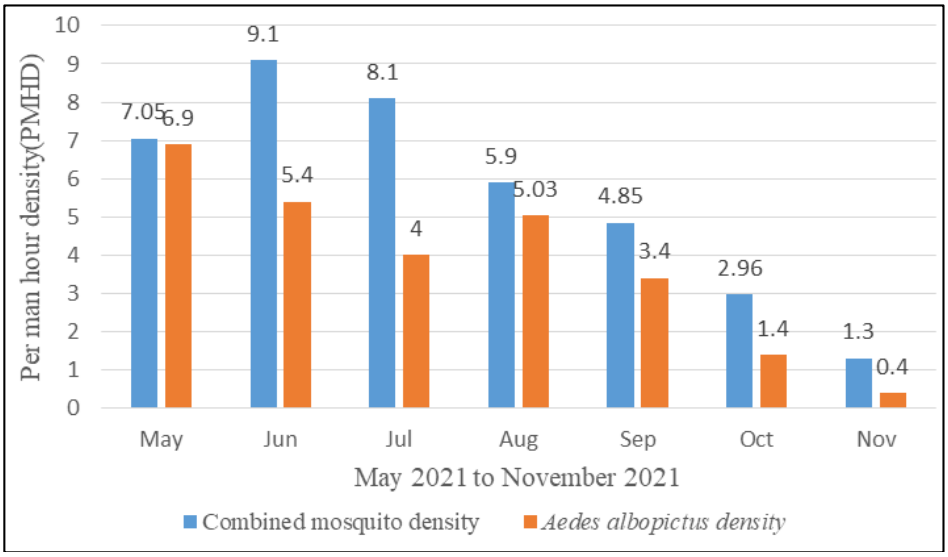

Fig 7: Per man hour density of mosquitoes in the urban areas of Kottayam district

4. Discussion

Mosquito fauna of 14 species belonging to 7 genera were recorded in the study area and all the species were already reported from different parts of Kerala [9, 10]. Out of the 14 species of mosquitoes recorded in the present study, 8 were reported as vectors of various diseases in different parts of the world. Among the *Aedes* species collected from the study area *Aedes albopictus* was reported as the secondary vector of dengue and chikungunya [11]. The primary vector *Aedes aegypti* was not reported in any of the study area in the present study. *Ae. Aegypti* was reported in urban areas of Thiruvananthapuram district of Kerala in an earlier study [12]. In the absence of the principal vector *Ae. Aegypti*, *Aedes albopictus* is effectively transmitting dengue virus in the study area. In several south-east Asian countries *Aedes albopictus* has incriminated with dengue virus [13]. In Kerala *Ae. Albopictus* was recognized as the primary vector for the transmission of Dengue and Chikungunya [14, 15]. The prevalence of *Ae. Albopictus* was maximum in urban areas compared to rural areas. Per domestic water storage containers were found to be the major breeding source for *Ae. Albopictus* in urban areas. Cement tanks, Plastic drums and cisterns were used to store water in these areas. Significant presence of unused or discarded latex collection containers were responsible for the profuse breeding of *Ae. Albopictus* in rural areas. Man hour density of total mosquitoes were found to be maximum during the monsoon month of June and July as rainfall positively influence the density mosquitoes[16]. However density of *Ae. Albopictus* were found to be maximum during the premonsoon month of May as the intermittent rainfall during the month of May provide water filled per domestic containers suitable for breeding of this

species. Heavy and continuous rainfall during the monsoon months cause flooding of containers which prevent the breeding of immatures in containers [12].

Armigeres subalbatus was found to be the most prevalent species in the rural areas of Kottayam district. This species is commonly found close to human dwellings with potential breeding habitat of poor sanitation that include polluted water such as septic tanks [17] and has been reported to be a vector of Japanese encephalitis virus [18]. In India, it has also been reported to be a vector of filarial worm *Wuchereria bancrofti* [19]. *Ae. Vittatus* was identified as the main vector of yellow fever in many parts of the world [20]. *Ae. Crysolineatus*, *Ae. Psudo Taeniatus* and *Ae. Cogilli* have no vector status. Of the three *Culex* species collected from the study sites *Cx. quinquefasciatus* is primary vector of bancroftian filariasis and suspected vector of Japanese encephalitis [21]. *Cx. gelidus* is also incriminated as vector of JE and *Cx. uniformis* is a non-vector mosquito species. Genus *Mansonia* was represented by only one species, *Mn. uniformis* and was incriminated as secondary vector of JE in Kerala [22, 23] and also have been implicated as vector of Brugian filariasis [24]. Of the two *Anopheles* species collected *An. Stephensi* is the primary vector of Malaria and *An. Subpictus* is a suspected vector of Malaria in India. Also Japanese encephalitis virus was isolated from *An. subpictus* during the JE outbreak in Kerala in the year 1996 [22]. Species such as *Hz. discripens*, *Tx. splendens* are generally considered as non-vector species.

Species such as *Ae. Albopictus*, *Ar. Subalbatus*, *Cx. crysolineatus*, *Cx Uniformis* constituted more than 75% of the total mosquito species collected from the study area. Species such as *Anopheles stephensi*, *Anopheles subpictus*, *Mansonia uniformis* were least abundant one as only few specimens were obtained during the study. In forest fringe areas rubber plantation associated latex collection containers and per domestic discarded containers were found to be the key breeding habitat for *Ae. Albopictus.* During rainy season rainwater collected in the latex collection cup forms the main breeding habitat for *Ae.albopictus*[4]. Small and large scale rubber plantation is common and interspersed in the forest fringe areas.

5. Conclusion

Even though different vector and non-vector mosquito species were being reported in the forest fringe areas of Kottayam district, the most prevalent species recorded was *Ae. Albopictus* especially in the urban areas. Extensive cultivation of rubber plants provide suitable situation for proliferation of *Aedes albopictus*. Since *Aedes* transmitted diseases such as dengue and chikungunya are being reported in the study area entomological surveillance and its significance can be used to halt the outbreak as shown in this study.

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