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AN ENTOMOLOGICAL STUDY ON THE COMPOSITION AND SEASONAL PREVALENCE OF MOSQUITOES IN CENTRAL KERALA, INDIA

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ABSTRACT

Diseases transmitted by mosquito vectors are of global importance. Knowledge on mosquito composition and their seasonal prevalence are the major prerequisites for assessing the risk of various mosquito-borne diseases in an area. Objectives of the study was to understand the composition and seasonal prevalence of mosquitoes in selected districts of Kerala state. Samples were collected from selected localities of central Kerala using standard methods for a period of three years. Samples were collected from 48 localities of the study areaduring pre-monsoon, monsoon and post-monsoon seasons. A total of 38 species belonging to 10 genera were recorded.Individual species showed seasonal variation in prevalence and population size. The recorded species include vectors of Dengue Fever, Chikungunya, Japanese Encephalitis, Malaria and Filariasis.

KEYWORDS: Vector, mosquito diversity, Man Hour Density.

INTRODUCTION

Amongthe various insect groups, mosquitoes always get special attention as vector and nuisance pests. Mosquito-borne diseases are among the world's leading causes of illness and death. The World Health Organization estimates that more than 300 million cases of mosquito-borne illnesses occur each year.

The recent emergence and resurgence of mosquito-borne diseases such as Dengue Fever (DF), Chikungunya (CG), Japanese Encephalitis (JE), Malaria and Filariasis caused serious public health problems in Kerala. Central Kerala can be considered as the epicentre of various vector-borne diseases. In fact, Arboviral diseases such as DF, CG and JE originated from Central Kerala which comprises Kottayam, Pathanamthitta, Alappuzha, Ernakulam and Idukki districts.

In Kerala, DF was first reported from Kottayam district of central Kerala in 1997 with 14 cases and 4 deaths (Tyagi et al, 2003). Since then, DF cases were reported from the district in a routine manner, except in 2000. In 1998, the number of confined cases increased to 67 with

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13 deaths. By 2001, DF which was confined to the district, spread to the neighbouring districts of Idukki and Ernakulum (Kalra and Prasittisuk, 2004). DF has now become prevalent in all the districts Kerala state. In the state, JE first appeared in the district of study along with the neighbouring Alappuzha district in the year 1996 (DHS, 1997). Since then, sporadic cases of JE were reported (John et al, 2004). CG, which appeared in epidemic form in 2006, added a new dimension to the entire scenario of mosquito-borne diseases in the district. Kottayam was one among the four most affected districts with CG, which was reported for the first time in Kerala (Kannan et al, 2009). It assumed alarming epidemic proportions in the district in 2007 and resulted in 10662 cases- the highest among the districts of Kerala (NVBDCP, 2010).

The major mosquito borne diseases like Malaria, Filariasis, Dengue, Chikungunya, Japanese Encephalitis, etc. continue to cause serious health concern in Kerala. However, detailed studies regarding mosquito diversity and seasonal prevalence in the selected districts are negligible. Available information on mosquitoes is derived from studies undertaken in different districts of Kerala in connection with the emergence of DF.These studies mainly considered Dengue vectors and some aspects of their breeding. The outbreaks of various mosquito-borne diseases, the lack of sufficient knowledge regarding mosquitoes warrant the importance of an entomological study in the district. Awareness on mosquito diversity and their seasonal prevalence are the prerequisites for assessing the risk of various mosquito-borne diseases and target specific mosquito control measures. The objective of the present study was to bring on record the diversity of mosquitoes and their seasonal prevalence in Kottayam and Idukki districts of central Kerala.

MATERIALS AND METHODS

DESIGN OF STUDY

Present research work was conducted by sample survey for a period of three years, from February 2008 to January 2011. Two districts-Kottayam and Idukki - of central Kerala were selected for study. Each calendar year was divided into three seasons such as pre-monsoon (February to May), monsoon (June to September) and post-monsoon (October to January).

STUDY AREA

Kottayam and Idukki districts are located towards the centre of Kerala state (Fig 1). Both the districts are heterogeneous in many respects and have their own peculiarities as detailed below (Kottayam, 2007; Idukki, 2007)

Physiography- Kottayam district has a total area of 2208 sq.km and lies between latitude 9°15' and 10°21' and longitude 76°22; and 77°25'. District is bordered on north by Ernakulum district, on the east by Idukki district and on south by Alappuzha and Pathanamthitta. Vembanad lake forms the western boundary. The district has no costal area.Idukki district has a total area of 4358 sq.km and lies between latitude 9°15'an 10°21'

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and longitude 76°37' and 77°25'. The district bound on the east by Tamil Nadu state, west by Ernakulum and Kottayam, south by Pathanamthita and north by Trichure districts. More than 50% of the area is covered by forest and about 97% of the district is covered by rugged mountains.

DEMOGRAPHY

According to the census 2011 Kottayam district had a population of 19.7 lakhs with a literacy rate of 97.48%. Population density per sq.km was 895. According to the census 2011 Idukki district had a population of 11.09 lakhs with a literacy rate of 95.60 %. Population density per sq.km was 255.

Climate- Kottayam district has a tropical climate. The district normally gets annual average rainfall of 3130.33 mm. The hot season from March to May, is followed by south- west monsoon from June to September. The month of October and November constitute the post monsoon season or north-east monsoon. Months of December to February form the winter. As far as Idukki is concerned climate shows variation from one area to another. The annual rainfall varies from 2500-4250 mm. East and north eastern regions get very low rainfall normally up to 1500 mm.

Agriculture- Agriculture forms the livelihood of the majority in both the districts. Cash crops as well as food crops are cultivated. In Kottayam Rubber is the major cash crop, grown in 109582 hectares – the largest area under rubber cultivation in the state. Paddy is the most important food crop cultivated in 25213 hectars. Other crops include tapioca, pine apple, plantain, ginger, tubes, vegetables etc. In Idukki agriculture is the main segment of the economy. Tea, cardamom, pepper coffee, rubber, coconut, etc are cultivated.

SELECTION OF SITES

For the convenience, number of localities for sample collection was fixed as 48. Of the 48 localities selected for the study, 24 belongs to Kottayam district while the rest (24) belongs to Idukki district.

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Figure 1.Map of Kerala showing study area

MOSQUITO COLLECTION METHODS

Adult mosquitoes were collected from each selected locality once in a season using standard methods (WHO, 1975) for a period of three years, from February 2008 to January 2011. Samples were collected from indoor and outdoor of human dwellings and animal sheds using aspirator and flash light from 7 am to 11 am and 6 pm to 9 pm. Mosquitoes were collected for 40 minutes from each catching site. Thus, a total of 4 Man Hours were employed in each locality per season.

Collected specimens were narcotized with petroleum ether and identified relevant taxonomic references (Christophers, 1933; Barraud, 1934; Sirivanakarn , 1989; Knight and Stone, 1977; Huang, 1979; Das *et al.,* 1990; Reuben *et al.,*1994; Das and Kaul, 1998; Reinert, 2000).

OBSERVATIONS

COMPOSITION OF MOSQUITO FAUNA

Present study gives a clear idea on the composition of mosquito fauna in the study area. A total of 12196 mosquitoes were collected during 1728 man-hours of collection from the study area. A total of 10 genera of mosquitoes were recorded. They were *Aedes, Anopheles, Armigeres, Culex, Coquilletidia, Heizmannia, Mansonia, Mimomyia, Toxorhynchites*and *Uranotaenia*. (Table 1). Genus *Culex* was represented by 16 species, followed by genus *Anopheles* by seven species, *Aedes* by six species, *Mansonia* by three species and one species

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each by genus *Armigeres, Coquilletidia, Heizmannia, Mimomyia, Toxorhynchites*and *Uranotaenia.*

Table 1.Generic composition of adult mosquitoes in study area

Genus	No. of species	Total No. of specimens collected	Percentage
Aedes	06	3236	26.5
Anopheles	07	137	01.1
Armigeres	01	2404	19.7
Coquillettidia	01	36	00.3
Culex	16	5180	42.5
Heizmannia	01	43	00.4
Mansonia	03	1052	08.6
Mimomyia	01	2	0.02
Toxorhynchites	01	79	00.7
Uranotaenia	01	27	00.2
Total	**38**	**12196**	**100.00**

Among the 10 genera, *Culex* was the predominant genus and was represented by 42.5 percentages of the total mosquitoes collected, followed by *Aedes* by 26.5 and *Armigeres* by 19.7 percentages (Fig 2). These three genera together constituted 88.7 percentage of the total collection.

A total of 38 species were recorded during the study (Table 2). Among the various species collected *Armigeressabalbatus* was the most predominant species with 2404 mosquitoes (19.7%), followed by *Aedes albopictus* with 2277 mosquitoes (18.6%) and *Culex tritaeniorhynchus* with 1509 mosquitoes (12.3%) (Fig.3). These three species together constituted more than 50 per cent of the total and the remaining 35 species constituted only less than 50 per cent of the total catches.

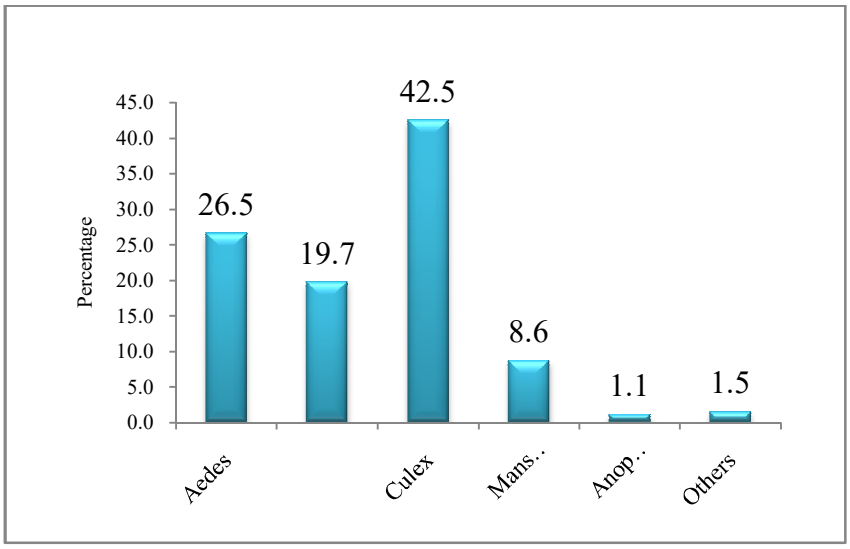

Figure 2.Percentage of mosquitoes collected from each genus

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SEASONAL PREVALENCE OF MOSQUITOES

Mosquito population showed quantitative and qualitative fluctuation in different seasons. A total of 5160 mosquitoes belonging to 30 species were recorded during the pre-monsoon season. *Ae. albopictus* was the most dominant species during the season with a MHD of 1.83, followed by *Ar. sabalbatus* with a MHD of 1.42. Total MHD during pre-monsoon period was estimated to be 8.96 (Table 2).

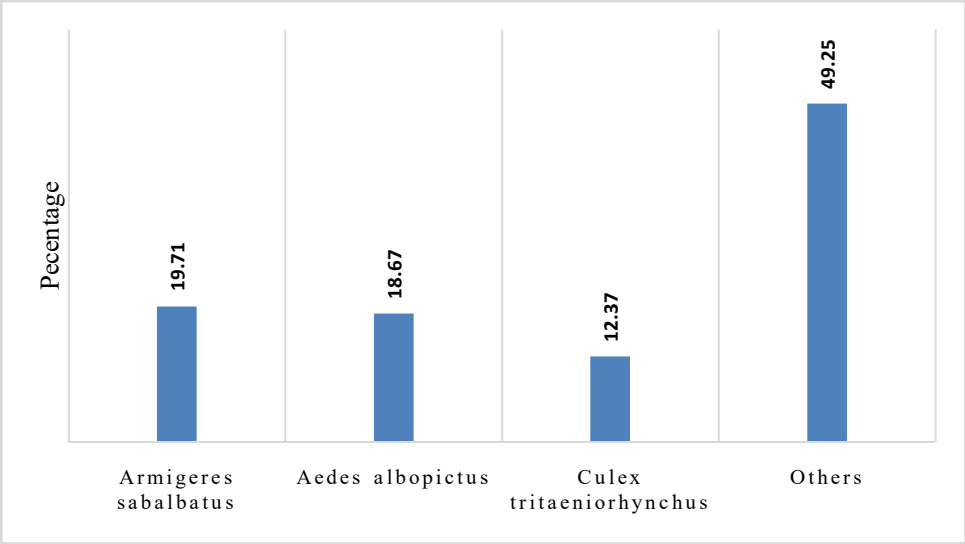

Figure 3.Relative abundance of major species

A total of 3406 mosquitoes belonging to 30 species were collected during the monsoon season. *Ae. albopictus* was the most dominant species during the monsoon season with a MHD of 1.49, followed by *Ar. sabalbatus* with a MHD of 1.09. The total MHD during the monsoon was 5.91 (Table 2).A total of 3630 mosquitoes belonging to 31 species were collected during the post-monsoon season. *Ar. sabalbatus* was the most dominant species during the season with a MHD of 1.65, followed by *Ae. albopictus* with a MHD of 0.63. The total MHD was estimated to be 6.30 (Table 2).

Table 2.Composition of mosquitoes and theirprevalence in different seasons

Sl No	Species	Pre-monsoon		Monsoon		Post-monsoon	
		No.	MHD	No.	MHD	No.	MHD
01	*Ae. aegypti*	0	0.000	5	0.009	0	0.000
02	*Ae. albopictus*	1055	1.832	858	1.490	364	0.632
03	*Ae. chrysolineatus*	57	0.099	240	0.417	100	0.174
04	*Ae.niveus*	0	0.000	32	0.056	2	0.003
05	*Ae. vexans*	69	0.120	64	0.111	102	0.177
06	*Ae. vittatus*	40	0.069	186	0.323	62	0.108
07	*An. barbirostris*	12	0.021	0	0.000	11	0.019
08	*An.jamessi*	3	0.005	0	0.000	0	0.000
09	*An. nigerrimus*	14	0.024	0	0.000	10	0.017
10	*An. pallidus*	5	0.009	0	0.000	11	0.019

11	*An. peditaeniatus*	2	0.003	0	0.000	0	0.000
12	*An. subpictus*	28	0.049	0	0.000	17	0.030
13	*An. vagus*	16	0.028	0	0.000	8	0.014
14	*Ar. sabalbatus*	819	1.422	632	1.097	953	1.655
15	*Cq.crassipes*	3	0.005	19	0.033	14	0.024
16	*Cx. bitaeniorhynchus*	322	0.559	91	0.158	242	0.420
17	*Cx. brevipalpis*	23	0.040	175	0.304	67	0.116
18	*Cx.fuscanus*	34	0.059	34	0.059	6	0.010
19	*Cx. fuscocephala*	4	0.007	21	0.036	4	0.007
20	*Cx. gelidus*	281	0.488	16	0.028	211	0.366
21	*Cx. infula*	8	0.014	3	0.005	0	0.000
22	*Cx.minutissimus*	0	0.000	3	0.005	0	0.000
23	*Cx. pallidothorax*	51	0.089	213	0.370	65	0.113
24	*Cx.pseudovishnui*	89	0.155	16	0.028	37	0.064
25	*Cx. quinquefasciatus*	569	0.988	173	0.300	273	0.474
26	*Cx.sitiens*	1	0.002	0	0.000	0	0.000
27	*Cx. tritaeniorhynchus*	984	1.708	54	0.094	471	0.818
28	*Cx.uniformis*	120	0.208	198	0.344	90	0.156
29	*Cx.univittatus*	0	0.000	23	0.040	9	0.016
30	*Cx.vishnui*	54	0.094	18	0.031	27	0.047
31	*Cx. whitmorei*	69	0.120	1	0.002	30	0.052
32	*Hz.chandi*	0	0.000	40	0.069	3	0.005
33	*Ma. annulifera*	13	0.023	45	0.078	39	0.068
34	*Ma. indiana*	22	0.038	58	0.101	54	0.094
35	*Ma.uniformis*	393	0.682	110	0.191	318	0.552
36	*Mi hybrida*	0	0.000	2	0.003	0	0.000
37	*Tx. splendens*	0	0.000	53	0.092	26	0.045
38	*Ur.novobscura*	0	0.000	23	0.040	4	0.007
		5160	**8.958**	**3406**	**5.913**	**3630**	**6.302**

DISCUSSION

There is a rich diversity of mosquitos in the study area. During the study 10 mosquito genera were observed viz, *Aedes, Anopheles, Armigeres, Coquillitidia, Culex, Heizmannia, Mansonia, Mimomyia, Toxorhynchites*and *Uranotaenia* (Table 1). These genera are represented by 38 species (Table 2). All the species were already reported from different parts of Kerala (Mariappan*et al.,* 1997; Hiriyan*et al*., 2003; Arunachalam *et al*., 2004; Thenmozhi*et al*., 2007). *Ar. sabalbatus* is the most abundant species, which constituted 19.7 % of the total. Mariappan*et al.,* (1997) recognized *Ar.sabalbatus* as the predominant nuisance mosquito in Kochi, Kerala as observed in the present study. *Ae.albopictus* comes next with 18.6%, followed by *Cx. tritaeniorhynchus* (12.3%), *Cx. quinquefasciatus* (8.33%), *Ma. uniformis* (6.7%), *Cx. bitaeniorhynchus* (5.37%) and *Cx. gelidus* (4.16%). These seven species together constituted more than 75 % of the total. Species such as *Ae. aegypti*, *Cx.*

sitiens, *An. peditaeniatus, An.jemessi, Cx. infula* and *Mi. hybrida* were least abundant one as only few specimens were obtained during the study.

Of the 38 species of mosquitoes collected 21 were incriminated as vectors of various diseases in many parts of the world (Table 3). Of the 16 Culex species collected, 10 are known vectors in India. *Cx.vishnui, Cx. pseudovishnui*, Cx. *tritaeniorhynchus* and *Cx. gelidus* are the common vectors of JE in different parts of the country. *Cx. quinquefasciatus*, *Cx. whitmorei, Cx. bitaeniorhynchus, Cx. infula* and *Cx. fuscocephala* were also incriminated as vectors of JE. *Cx. whitmorei, Cx. bitaeniorhynchus* and *Cx. fuscanus*were also incriminated as vectors of JE. *Cx. tritaeniorhynchus* is identified as the primary JE vector in Kerala (Arunachalam *et al.,* 2004). *Cx. quinquefasciatus* is primary vector for Bancroftian Filariasis (BF) and suspected vector of JE (Mourya, 1989).

Of the six Aedes species recorded, *Ae. aegypti* is known as primary vector of DF and CG while *Ae. albopictus* is a secondary vector in different parts of world, including India (WHO, 1999; Jupp and McIntosh, 1988). However, in the State of Kerala, *Ae. albopictus* is recognized as the primary vector and plays a significant role in transmission of DF and CG (Kanann*et al.,* 2009; Thenmozhi, *et al*., 2007). *Ae. niveus* has been incriminated as secondary vector of DF in some parts of the world (Huang, 1979). *Ae. vittatus*and *Ae. aegypti* were identified as the main vectors of Yellow fever in many parts of the world (Bruce, 2005).

Genus Mansonia was represented by three species. *Ma. annulifera, Ma. indiana*and *Ma. uniformis* were incriminated as secondary vectors of JE in Kerala (Dhanda*et al.,* 1997; Arunachalam *et al*., 2004). They have also been implicated as vectors of Brugian filariasis (BF) in the erstwhile Travancore area of Kerala as early as 1932 (Iyengar, 1938).

Table 3.Medically important vector mosquitoes identified from study area

Sl No	Species	Vector status*
01	*Ae. aegypti*	*DF, CG,YF*
02	*Ae. albopictus*	*DF,CG*
03	*Ae. niveus*	*DF*
04	*Ae. vittatus*	*YF,DF*
05	*An. barbirostris*	*MF,HF*
06	*An. nigerrimus*	*MF, HF*
07	*An. pallidus*	*MF*
08	*An. subpictus*	*JE,HF*
09	*Cx. bitaeniorhynchus*	*JE*
10	*Cx. fuscanus*	*MF*
11	*Cx. fuscocephala*	*JE*
12	*Cx. gelidus*	*JE*
13	*Cx. infula*	*JE*
14	*Cx. pseudovishnui*	*JE*
15	*Cx. quinquefasciatus*	*JE, BF*
16	*Cx. whitmorei*	*JE*
17	*Cx. tritaeniorhynchus*	*JE*

18	*Cx. vishnui*	*JE*
19	*Ma. annulifera*	*JE*
20	*Ma. indiana*	*JE*
21	*Ma. uniformis*	*JE*

*Primary, secondary and suspected vectors

JE virus was isolated from *An. subpictus* during the JE outbreak in Kerala in 1996 (Dhanda*et al.,* 1997). No primary vector of Malaria was detected from the study area. However,*An. subpictus* and *An. pallidu*s are suspected vectors for malaria in India (Wattal*et al.,* 1961)and *An. barbirostris* is a vector for malaria in Indonesia (Wattal*et al.,* 1961). Detection of Anopheles mosquitoes is of great significance in the context of reports of malaria in the study districts. *An. barbirostris, An. nigerrimus* and *An. subpictus* are vectors of Human Filariasis (HF) in India (Nagpal and Sharma, 1995; Ragavan,1969). *An. jamesii*and *An. vagus* are considered as non vectors (Nagpal and Sharma, 1995).Species such as *Ar. sabalbatus, Cq. crassipes, Hz. chandi, Tx. splendens* and *Ur. novobscura* are generally considered as non-vectors. Being the prominent species,*Ar. sabalbatus*causes a serious biting nuisance in the area.

In the present work a sincere attempt was made to understand the seasonal prevalence of mosquitoes and their population fluctuation in the study area. Species diversity not varied much with season- monsoon season (30 species), post monsoon season (31) and pre-monsoon seasons (30) (Table 2). Twenty-one species were found throughout seasons. Maximum Total Man Hour Density was noted during the pre-monsoon season (8.95), followed by post-monsoon (6.3) and monsoon seasons (5.9). Ie, the combined mosquito population gradually built up during post-monsoon, reached its maximum during pre-monsoon and declined during monsoon. *Ar. sabalbatus* and *Ae. albopictus* together played a major role in enhancing the total population during pre-monsoon. These two were the dominant species in the district and were abundant in all seasons in both districts. Intermittent rain falls and relatively high temperature during pre-monsoon season in these areas contribute to the generation of breeding habitats suitable for these species and their higher density. Many of the individual species showed population fluctuation in different seasons. Among the major species, *Cx. bitaeniorhynchus, Cx. quinquefasciatus, Cx. tritaeniorhynchus, Cx. gelidus* and *Ma. uniformis* showed maximum population during pre-monsoon season, followed by a decline during monsoon. Similar findings were reported before (Arunachalam *et al.,* 2004). Population of *Cx. pallidothorax, Cx. brevipalpis, Cx. uniformis, Ae. chrysolineatus*and *Ae. vittatus* started building up during pre-monsoon and reached their maximum during monsoon season. Almost all the individual species showed a rapid decline in the population during monsoon. The pattern of rainfall and agriculture may affect vector population size (Arunachalam *et al.,* 2004; Takagi *et al.,* 1997; Gubler*et al.,* 2001; Woodruff *et al.,* 2002; Kelly *et al.,* 2004). A high density of *Cx. tritaeniorhynchus* was recorded in paddy cultivated areas of South Arcot and Madurai districts of Tamil Nadu and Mandya district of Karnataka (Gajana*et al.,* 1997; Geevarghese*et al.,* 1994). In some cases, increased rainfall may increase larval habitat and vector population by creating a new habitat, while excessive rain would

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eliminate habitats through flooding, thus, decreasing the vector population (Gubler*et al.,* 2001; Woodruff *et al.,* 2002; Kelly *et al.,* 2004). During the dry season limited rainfall can also create new habitats, when water in the rivers is drawn into pools, providing the perfect breeding sites for a number of mosquito species and thus favouring diseases transmission (Gubler*et al.,* 2001).

CONCLUSION

Study area showed a rich diversity of mosquitoes and relatively high density of few species such as *Armigeressabalbatus* and *Aedes albopictus*. Forest cover, high rainfall, high relative humidity and moderate temperature along with crops such as rice, rubber, cocoa, pineapple, coconut and arecanut make suitable conditions for mosquito breeding and proliferation. While Armigeres*sabalbatus*acts as a serious biting nuisance*Aedes albopictus* acts as a serious vector of DF and CG. The study has also revealed the presence of many other vector mosquito species of various communicable diseases such as JE, Malaria and filariasis. Identification of breeding sources and their reduction is essential for the control of mosquitoes and subsequently the mosquito borne-diseases.

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