ISSN: **2348-5906**
CODEN: **IJMRK2**
IJMR 2015; 2 (1): 42-46

Received: 05-11-2014
Accepted: 17-12-2015

K.S. Malar
Department of Zoology,
N.M.S.S.V.N College,
Nagamalai, Madurai, India.

R. Gopal
PG and Research Department of
Zoology, Yadava College,
Madurai India.

R. Selvaraj Pandian
PG and Research Department of
Zoology, The American College,
Madurai, India.

For Correspondence:
K.S. Malar
Associate Professor and Head,
Department of Zoology,
N.M.S.S.V.N College,
Nagamalai, Madurai–625 019,
Tamil Nadu, India.

Influential inflicts of monsoon and agricultural practices among the population density of mosquitoes in the agro-rural villages of Madurai

K.S. Malar, R. Gopal and R. Selvaraj Pandian

Abstract
Proliferation of mosquitoes were greatly influenced by the monsoon rains and the irrigtion practices among the agrorural settlements of surrounding villages in the Samanar hills of Madurai. Nearly 31 species belonging to *Aedes, Anopheles, Culex, Armigeres* and *Mansonia* were collected. Predominant abundance of *Cx. quinquefasciatus Cx. tritaeniorhynchus, Anopheles hyrcanus groups, Ae. aegypti, Ae. albopictus* and *Ar. subalbatus* were observed. On the other hand species abundance and diversity peaked during the monsoon rains and paddy cultivating months ranging from September 2006 to January 2007 than during the summer or winter months. Henceforth monsoon oriented agricultural practices enhances the proliferation of vector mosquito and their density.

Keywords: Mosquito, agricultural practices, Agro rural villages, density, monsoon rains, species of *Aedes, Anopheles, Culex, Mansonia* and *Armigeres.*

1. Introduction

Changing climatic and weather patterns influence the density of mosquitoes. The agro rural areas may be severely affected with the onset of monsoon rains at different stages of rice cultivation and formation of aquatic habitats, new grass lands, non-irrigated flooded field, ponds, stagnant water pools and puddles that certainly influence the mosquito bionomics. The global climate has generally widened the health inequalities and epidemic outbreaks in general [1]. Densities of mosquitoes [2] are mostly influenced by the environment in which it dwells. Their abundance strongly depends on the weather and the ecological niches to which they are closely linked. In addition to the availability of water, structural landscape for irrigation and cultivation of crops, dam, rivers, water stored ponds and rains were also associated with a wide spectrum of mosquito fauna and the density of mosquito proliferation was also influenced by the favorable prevalence of ambient condition.

Seasonality being a key component of climatic complexes interplays with factors such as temperature, rainfall, humidity, wind etc., that determines the overall effects of climate in the prevalence of mosquito-borne diseases. Many mosquito related diseases that occur in tropics are seasonal [3]. In general, the four common seasons in India are (i) Southwest monsoon (ii) Northeast monsoon (iii) summer and (iv) winter. Monsoon rains initiates paddy cultivation in many parts of south India enhancing mosquito proliferation and the abundant occurrence of *Aedes, Anopheles* and *Culex* species that are more diverse in the rainy season than during the dry season [4] and population of mosquito fauna fluctuated with the seasonal dynamics of vegetation [5]. Therefore the present study aims to analyse the impact of mosquito density in the agricultural villages of Samanar hills-Thiruparakunduram panchyat –Madurai- India, during the monsoon rains.

2. Materials and Methods

By adopting the method followed by Pandian and Chandrashekaran [6] and Reuben [7] the adult and larvae mosquitoes were collected and reared to adults respectively. The species were identified [8] with the help of the entomologist of ICMR-CRME, Madurai.

The study comprised of four quarterly seasonal collections, based upon the Southwest and Northeast monsoon rains and the water released from Periyar dam for irrigation practices in the villages surrounding the Samanar hills, Madurai, Tamil Nadu, India. They are (1) I Season (IS = Sep 2006-Nov 2006), (2) II Season (IIS = Dec 2006 – Feb 2007), (3) III Season (III S = Mar 2007 – May 2007) and (4) IV Season (IV S = June 2007 – Aug 2007)

2.1 Correlation analysis
Karl Pearson's co-efficient correlation analysis [9] deals with the association or co-variation between two or more variables. In the present study the relationship between density of species to seasons were analysed.

3. Results
The density of the *Aedes*, *Anopheles, Armigeres*, *Culex* and *Mansonia* mosquitoes in the agricultural rural villages during the different season revealed that the density of the *Culex* species was dominant followed by *Aedes*, *Anopheles*, *Armigeres* and *Mansonia*. Higher population peaks that occurred during the IS and declined to smaller peaks during the IIIS i.e. from Mar 2007-May 2007. *Aedes, Anopheles* and *Culex species* abundance during the I, II, III and IV seasons of the study period was shown in the fig.1. Among the *Culex* species *Culex quinquefasciatus* and *Culex tritaeniorhynchus* was found in abundance during the IS, IIS & IVS, but the predominant occurrence of *Aedes* and *Anopheles* species fluctuated variably during the IIIS (Mar-May 2007) (Fig.1). Species of *Aedes* and *Culex* occurred in abundance than the *Anopheles* species. Even during the summer months density of *Cx. quinquefasciatus* and *Cx. tritaeniorhynchus* was higher. Whereas the density of *Ar. subalbatus* and *Mn. uniformis* was comparatively more during Dec 2006-Feb 2007 (IIS). Density of *Mansonia uniformis* increased during IIS than the IS and it was vice versa with *Armigeres subalbatus*. Thus seasonal influence on the inter and intrageneric variation of the species was predominant in the study area.
The relative abundance of the species in the selected sites revealed that it was higher during Dec 2006-Feb 2007 than during I S, III S and IV S comparatively (Table 1). The relative abundance of mosquito species in the selected sites was nine and seven during the IIS and IS respectively and five (III S) and four (IV S) species during the other season. However, the larval density during the different seasons of the mosquito species in the different villages was not the same, as it fluctuated during the different seasons of the study period Sep 2006-Aug 2007. Abundant larval collection of *Culex quinquefasciatus* and *Culex tritaeniorhynchus* exhibited three major peaks (IS, IIS & IVS) and minor peaks during the IIIS (Fig. 2).
The correlation analysis between the species and seasons in a pair wise (six pair) combination showed a high positive correlation during the different season emphasizing the influence of seasonal rains on mosquito species diversity and density. The correlation values ranged between +0.89 – 0.94 (Table 2).

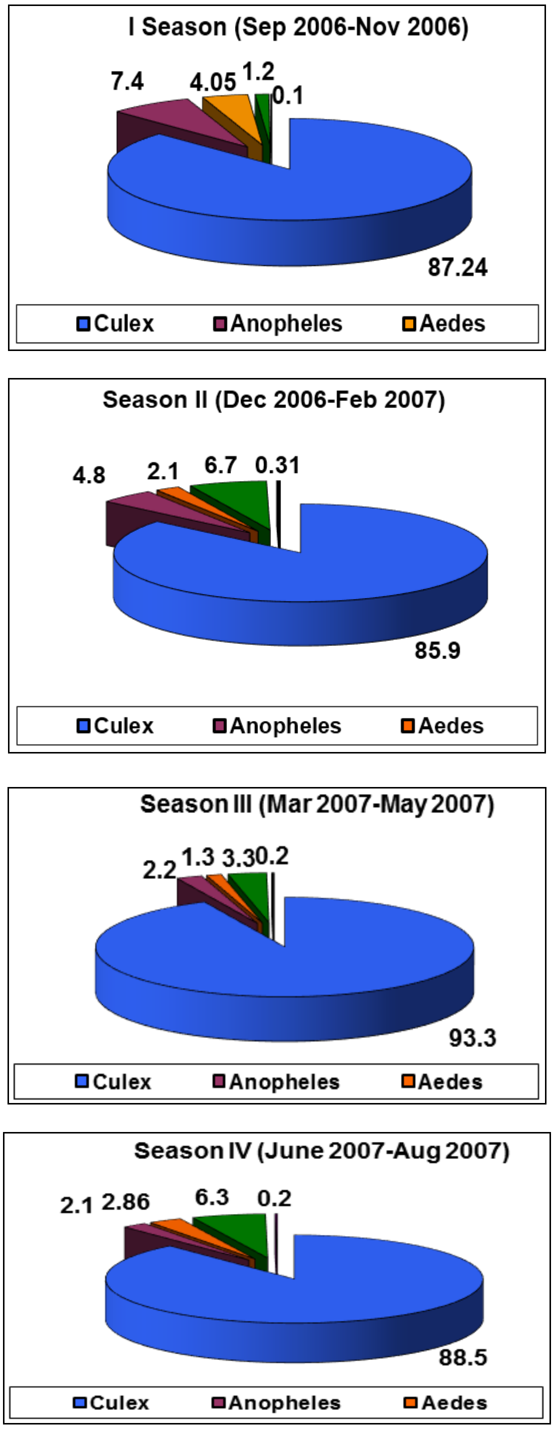

Fig 1: Density of mosquito genus recorded in the study area during the different seasons of the study period (Sep 2006- Aug 2007)

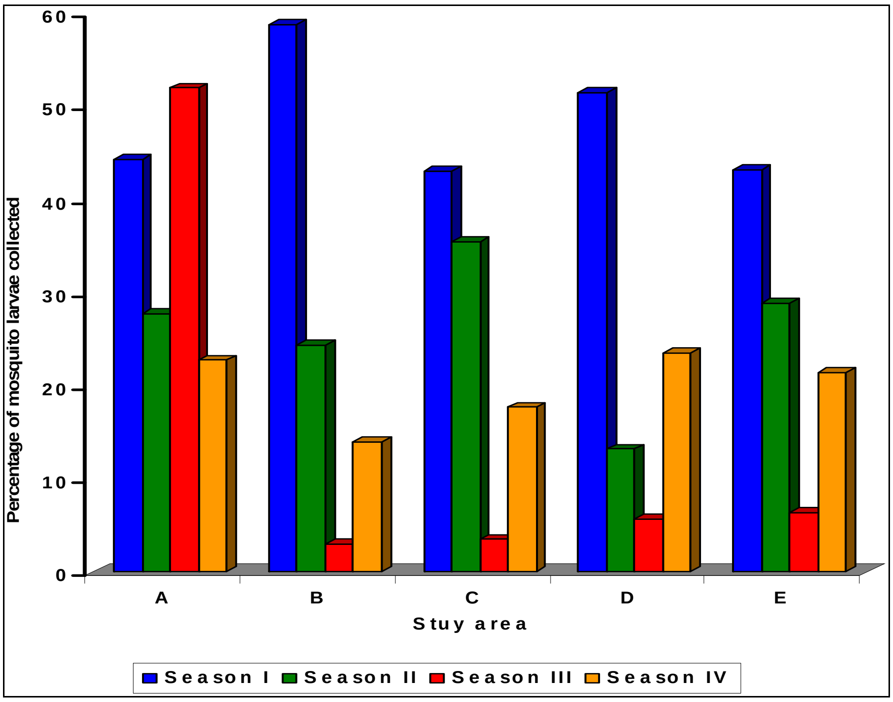

Fig 2: Percentage of mosquito larvae collected in the study area (Village - A: Melakuilkudi, B: Kelakuilkudi, C: Vadivelkarai, D: Sambakudi & E: Pudukulum) during the different seasons of the study period (Sep 2006-Aug 2007)

Table 1: Total number of mosquito species collected during the different seasons of the study period (Sep 2006-Aug 2007)

Sl. No.	Name of the mosquito species	Number of mosquitoes collected during seasons				Total
		Sep 2006- Nov 2006	Dec2006Feb2007	Mar2007May2007	June 2007 Aug2007	
	Aedes (Stegomyia) *aegypti*	10	6	1	8	25
	Aedes (Stegomyia) *albopictus*	54	33	1	22	110
	Aedes (Aedimorphus) *caecus*	51	7	3	9	70
	Aedes(Neomelaniconion)*lineatopennis*	32	14	-	3	49
	Aedes (Aedimorphus) *pallidostriatus*	21	6	-	-	27
	Aedes (Aedimorphus) *pipersalatus*	26	1	-	1	28
	Aedes (Mucidus) *scatophagoides*	20	8	1	-	29
	Aedes (Aedimorphus) *scutellaris*	1	2	1	-	4
	Aedes (Aedomyia) *venustipes*	1	-	-	-	1
	Aedes (Aedimorphus) *vexans*	159	59	11	47	276
	Aedes (Aedimorphus) *vittatus*	17	9	5	5	36
	Anopheles (Anopheles) *barbirostris*	72	12	-	2	86
	Anopheles (Anopheles) *nigerrimus*	17	5	-	-	22
	Anopheles (Cellia) *pallidus*	59	17	2	5	83
	Anopheles (Anopheles) *peditaeniatus*	270	251	25	46	592
	Anopheles (Anopheles) *stephensi*	58	-	-	-	58
	Anopheles (Cellia) *subpictus*	221	36	6	11	274
	Anopheles (Cellia) *vagus*	20	6	-	5	31
	Armigeres (Armigeres) *subalbatus*	116	460	56	210	842
	Culex (Culex) *bitaeniorhynchus*	68	46	1	26	141
	Culex (Culex) *fuscanus*	8	14	-	10	32
	Culex (Culex) *fuscocephalus*	1	8	1	6	16
	Culex (Culex) *gelidus*	32	26	3	12	73
	Culex (Culex) *halifaxii*	10	2	-	3	15
	Culex (Culex) *infula*	248	118	4	37	407
	Culex (Culex) *pseudovishnui*	32	23	-	18	73
	Culex (Culex) *quinquefasciatus*	3956	3089	1083	2211	10339
	Culex (Culex) *tritaeniorhynchus*	4059	2485	503	605	7652
	Culex (Culex) *vishnui*	28	28	1	10	67
	Culex (Culex) *whitmorei*	5	14	2	5	26
	Mansonia (Mansonioides) *uniformis*	10	21	3	8	42
	Total	9682	6806	1713	3325	21526

(**Note:** column & row details are needed, since month and season variation in mosquito densities differ in their occurrence; SI. No. – shows the number of mosquito

Table 2: The correlation values between the density of mosquitoes during different seasons

Sl. No.	Seasons	Correlation value
1	Season I and II	+ 0.986099
2	Season I and III	+ 0.927897
3	Season I and IV	+ 0.848319
4	Season II and III	+ 0.965798
5	Season II and IV	+ 0.910808
6	Season III and IV	+ 0.983682

4. Discussion

Impact of climatic changes on the temporal variation in the abundance of the encephalitis virus vector mosquito *Culex tarsalis* was linked significantly with coincident and antecedent measures of regions of climate, including temperature, precipitation, snow pack and the El Nino, southern oscillation anamoly [2]. Thus the correlation between winter and spring precipitation and snow pack and spring, *Culex tarsalis* abundance was stronger than correlation with summer abundance. This in similar to the present study of correlation as abundance of Culex species occurred during the rainy and winter months (Sep 2006-Feb 2007 & June 2007-Aug 2007) than during the summer months (March 2007-May 2007).

Okogun *et al.* [10] observed that the accumulated monsoon rainfall habitats accelerated the temperature and a high relative humidity favored more of *Aedes* and *Culex* during November-March than the *Anopheles* mosquitoes. Similarly the recorded 31 species in the Amazon rainforest was more diverse in the rainy season than during the dry season [11]. As in the case of the present study 31 species has been observed during Sep 2006 to Feb 2007. In addition, populations of *Aedes vexans* showed seasonal differences in habitats containing stagnant water, grassland and agriculture. But *Anopheles* species peaked during rainfall [12]. High population peaks of mosquitoes were observed between April and June and minor peaks between September and November were observed during seasonal rainfall [13].

Sathiskumar and Vijayan (2005) [14] observed an unexpected availability of species density and diversity during monsoon (June -September) post-monsoon (October-January) and pre-monsoon (February-May) in the state of Goa, India and *Ae. aegypti* was seasonally unstable and monsoon dependent. Abundant prevalence of larva and adult were noted during the dry (April 2000) and wet season (July 2000) in rural and urban settlement [15].

Reuda *et al*. (2010) [5] observed the occurrence of *An. hyrcanus* group larvae in the rice paddy field (24%), irrigation ditches (23.4%), ponds (17.0%), stream margins and pools (12.0%). The species composition of *Anopheles* larvae varied in different habitats of selected places. *Anopheles* population also fluctuated with the seasonal dynamics of vegetation index during 2007. As high percentage of *Anopheles hyrcanus* species were collected particularly during cultivation coincides with the above observation. In Gambia, *Anopheles gambiae* s.I. population expanded during and immediately after a single annual rainy season that lasted from June to October. The number of mosquitoes increased towards the end of dry season when humidity increased. Adult collections were predominated by *An. melas* (86%) than *Anopheles gambiae* s.I. (10%) and *An. arabiensis* (3%) were also present throughout the year. The local variation during the dry season is likely to influence the persistence of vector mosquito and the spatially variable transmission intensity among communities in turn during the rainy season and it could be evaluated further as a potential means of targeting control [16]. Higher vector densities were reported throughout the rice growing seasons. *An. gambiae* s.I. was particularly high during August and the relative frequency was 90.2%. But high frequencies of *An. funestus* were observed at the end of the rainy season and during the dry cold season in the villages [16].

Seasonal diversity of vector abundance in Gorakhpur district of U.P., India was recorded, in which bimodal pattern with short and tall peaks were observed during March and September respectively among the *Cx. tritaeniorhynchus*. But, *Cx. pseudovishnui, Cx. whitmorei, Cx. gelidus, An. subpictus, An. peditaeniatus* and *Mn. uniformis* vector population peaked during August and November when population of *Cx. bitaeniorhynchus* were on the decline. However the vector populations were more active during the period of paddy cultivation [17]. The above findings supports the present study as a predominant bimodal peaks were recorded during August and September and the abundant occurrence of *Cx. tritaeniorhynchus* was high during the intensive paddy irrigation seasons only. After the paddy harvest the population tend to decrease. Further, *Cx. tritaeniorhynchus* was the most collected species in each month, but in November *Cx. gelidus* was found in abundance [18].

The density of *Cx. tritaeniorhynchus* was highest in the paddy cultivated areas during September–November that coincided with the observations made in the Bellary district of Andhra Pradesh of India, two rice crops grown during January-April and July-December in which *Cx. tritaeniorhynchus* increased in abundance during February and October and also in double (paddy) crop cultivated areas of South Arcot and Madurai district of Tamil Nadu and Mandya district of Karnataka [19, 20, 21] 19. High biting density of *Cx. quinquefasciatus* was observed during March i.e. 44.29 PMHD (Per Man Hour Density). The present finding falls in line with the above observation as *Cx. tritaeniorhynchus* and *Cx. quinquefasciatus* were the dominant during monsoon season of September-November and December-February based on the water released for cultivation.

Henceforth the onset of monsoon rains may be one of the major factors in determining the bionomics of mosquitoes in a typical agro rural ecosystem. The study of the findings on seasonal diversity and density of mosquitoes were important for public health decision-making as it could be related to adult mosquito surveillance and mosquito control. To implement any mosquito, management or control measure it is necessary to have a holistic approach about the mosquito fauna and the present study is one such. Climate dependent model to predict mosquito abundance can also be designed to control vector borne diseases [22].

5. Conclusion

Pathogens associated with vector borne zoonoses occur in enzootic cycles within nature which in turn respond to changes in environmental stimulation. Human involvement in these cycles and hence the occurrence of human disease, is often to act as incidental hosts. From a public health perspective our ability to better predict human outbreaks of these diseases and prepare interaction and mitigation strategies relies upon understanding the cycle of pathogen transmission through population.

A combination of abundant seasonal rainfall, tropical temperatures and a high relative humidity accounts for the intense mosquito breeding conditions during the seasonal variation study. This is further aggravated by the human activities. Availability of water collection with suitable fauna, flora and physio chemical composition of the aquatic medium might be a limiting or unlimiting factor to mosquito oviposition and breeding. A long duration of wet months (Sep-Feb and June-Aug) followed by irrigation and abundant breeding sites in a variety of domestic water collections, pools, sewages, accumulating waste host and in addition the socio-economic status [23] could increase mosquito vector diversity, abundance and vectorial capacity. Of all seasonal variations influence the breeding of the genus *Aedes*, *Anopheles*, *Armigeres*, *Culex* and *Mansonia*. Hence a multifacet approach of the mosquito diversity and density, the impact of seasonal variation on it is necessary for a clear understanding to implement any appropriate vector control methods to eradicate the vector borne diseases.

6. Acknowledgement
The author acknowledges with gratitude to the UGC XI plan Delhi, India for rewarding the FIP to complete the Ph.D and also I thank the ICMR (CRME) Madurai. The Paper is a part of the Ph.D work.

7. References

1. Sunyer J, Grimalt J. Global climate change, widening health inequalities and epidemiology. Int J Epidemiol 2006; 35(2):213-216.
2. Reisen WKD, Cayan M, Tyree BCM, Eldridge B, Dettinger M. Impact of climate variation on mosquito abundance in California. J Vec Ecol 2008; 33:89-98.
3. Reiter R. Climate change and mosquito borne diseases. Environ Hlth Perspect 2001; 109:141-161.
4. Overgaard HJ, Tsuda Y, Suwonkerd W, Takagi M. Characteristic of *Anopheles minimus* Theobald (Diptera: Culicidae) larval habitats in Northern Thailand. Environ Entomol 2002; 31:134-141.
5. Rueda LM, Tracy B, Henng C, Sung-Tae C, Terry A K, Desmond F *et al*. Species composition larval habitats, seasonal occurrence and distribution of potential malaria vectors and associated species of Anopheles (Diptera: Culicidae) from the Republic of Korea. Malaria J 2010; 9:55.
6. Pandian RS, Chandrashekaran MK. Rhythms in the biting behaviour of mosquito, *Armigeres subalbatus*. Oecologia (Berl) 1980; 47:89-95.
7. Reuben R. A report on mosquitoes collected in the Krishna-Godavari delta, Andhra Pradesh. Indian J Med Res 1978; 68:603-609.
8. Barraud PJ. The fauna of British India including Ceylon and Burma, Diptera. Family Culicidae. Tribes Megarhini and Culicin. Taylor and Francis, London, 1934, 5.
9. Zar JH. Biostatistical analysis, Edn, Singapore: Pearson Education (Singapore) (P) Ltd. New Delhi, (Indian Branch) 1999; 4:1-663.
10. Okogun GRA, Jude C. Anosike ANO, Bethran EB. Nwoke. Ecology of mosquitoes of Midwestern Nigeria. J vector Borne Dis 2005; 42:1-8.
11. Juliao GR, Abad-Franch F, Lourence-de-Oliveira R, Luz SLB. Measuring mosquito diversity patterns in an Amazonian Terra Firme Rain forest. J Med Entomol 2010; 47(2):121-128(8).
12. Diuk-Wasser MA, Bagayayoko M, Sogoba N, Dolo G, Toure MB, Traora SF *et al*. Mapping rice field anopheline breeding habitats in Mali, West Africa, using Landsat ETM+sensor data. Int J Remote Sens 2004; 25:359-376.
13. Onyido AE, Ezike VI, Ozumba NA, Nwosu EO, Ikpeze OO, Obiukwu MO *et al*. Crepuscular man-biting mosquitoes of a tropical zoological garden in Engu, South Eastern Nigeria. Int J Parasit Dis 2010; 4:1.
14. Sathiskumar, Vijayan VA. Mosquito fauna and breeding habitats in the rural areas of Mysore and Mandya districts, Karnataka State, India. Entomon 2005; 30(2):123-129.
15. Mahadev PV, Fulmali PV, Mistra AC. A preliminary study of multi-level geographic distribution and Prevalence of Aedes aegypti (Diptera: Culicidae) in the state of Goa, India. Ind J Med Res 2004; 120(3):173-82.
16. Jawara M, Margaret P, Chris JD, Davis CN, Ebrima J, Claus B *et al.* Dry season ecology of *Anopheles gambiae* complex mosquitoes in the Gambia. Malaria Journal 2008; 7:156.
17. Kanojia PC, Shetty PS, Geevarghese G. A long term study on vector abundance and seasonal prevalence in relation to the occurrence of Japanese encephalitis in Gorakhpur district, Uttar Pradesh. Indian J Med Res 2003; 117:104-10.
18. Tiawsirisup S, Nuchprayoon S. Mosquito distribution and Japanese encephalitis virus infection in the immigration bird (*Asianopenbilled stork*) nested area in Pathum Thani Province, Central Thailand. Parasitol Res 2010; 106(4):907-10.
19. Mani TR, Rao CV, Rajendran R, Devaputra M, Prasanna Y, Hanumaiah A. Surveillance for Japanese Encephalitis in villages near Madurai, Tamil Nadu, India. Trans R Soc Trop Med Hyg 1991; 85:287-91.
20. Geevarghese G, Mishra AC, Jacob PG, Bhat HR. Studies on the mosquito vectors of Japanese Encephalitis virus in Mandy district, Karnataka, India. Southeast Asian J Trop Med Pub Hlth 1994; 25:378-82.
21. Gajanana A, Rajendran R, Samuel PP, Thenmozhi V, Tsai TF, Kimura-Kuroda J *et al*. Japanese encephalitis in South Arcot district, Tamil Nadu, India: a three year longitudinal study of vector abundance and infection frequency. J Med Entomol 1997; 34:651-9.
22. Schaeffer B, Bernard M, Suzanne T. Using a climate-dependent model to predict mosquito abundance: Application to *Aedes* (Stegomyia) africanus and *Aedes* (Diceromyia) *furcifer* (Diptera: Culicidae). Infection Genetics and Evolution 2008; 8(4):422-432.
23. Arunachalam N, Susilowati T, Fe Espino, Pattamporn K, Wimal A, Khin T *et al*. Eco-biosocial determinants of dengue vector breeding: a multicountry study in urban and peri urban Asia. Bull World Health Organ 2010; 88:173-184.