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Biting Behaviour of The Filarial Vector Mosquito, *Culex quinquefasciatus* Say, in an Urban Area

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Abstract

Mosquitoes depend on blood meal for the development of their eggs into offsprings. By knowing the biting behaviour of mosquitoes, we may control mosquito-borne diseases and manage the mosquitoe menace successfully. The present study has been designed to study the biting behaviour of the filarial vector, *Culex quinquefasciatus* Say, in Madurai, Tamil Nadu, India from July to November 2006. This period was selected as mosquitoes are prevalent during this rainy season. Biting was more during September, October and November and the maximum of 28 caught/man/hour was recorded in November. It is predominantly an exophilic biter, but biting was also noticed as maximum inside the house during July in the study. The density of the biting population in the first floor was more than that of the second floor, which indicated the existence of vertical stratification in the biting behaviour of *Cx quinquefasciatus*.

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Introduction

Mosquitoes are found throughout the world, except Antarctica. They belong to the order, Diptera of the class Insecta. Members of the genera *Anopheles, Culex* and *Aedes* mainly bite human beings. Mosquitoes affect human welfare by direct annoyance and by transmission of pathogens causing diseases like malaria, filariasis, chikungunya, Japanese encephalitis, and dengue fever in man and a variety of diseases in other animals. They transmit diseases to more than seventy crores of people annually and will be responsible for the deaths of 1 of every 17 people currently living. Hence for the control of mosquitoes, many states and agencies have established mosquito control programs [1,2,3,4,5].

As the vector and nonvector mosquitoes are multiplying in large numbers, it becomes the immediate need of the hour to use a suitable technology and all available management techniques to bring out an effective control of mosquitoes in a cost effective manner. In addition to this, the problem of the management of mosquitoes in different areas is not uniform and the variation is mainly due to dynamic and differential nature of the mosquito population. As the mosquitoes are the vectors of many important diseases of man, knowledge on their faunal composition and seasonal variations is quite important [6,7,8].

The population density and species diversity of mosquitoes have been increasing extensively in the urban environment, due to the rapid growth of population and the construction of buildings in an unplanned and unbalanced manner. The paucity of functional sewage system has also led to the emergence of stagnating water pools and puddles. These water bodies are the most preferred breeding habitats for *Culex quinquefasciatus* Say, the main vector of *Wuchereria bancrofti*. It also transmits Japanese encephalitis [9,10,11]. *Cx. quinquefasciatus* is a cosmopolitan mosquito which is found in most part of the world. In particular, it is most abundant in human settlements in tropical and temperate countries. It is highly associated with human dwellings and also responsible for transmission of several dreadful diseases to human beings. The female *Cx. quinquefasciatus* mosquitoes prefer to lay their eggs in places where the decomposed organic matters are rich such as sewage effluents and septic tanks. However, immature stages of this mosquito can be seen in artificial containers frequently filled with organic rich or polluted water. *Cx. quinquefasciatus*, the southern house mosquito, has been very well studied in recent times due to its major role in transmission of diseases in human beings [12,13]. Along with its medical consequences, *Cx. quinquefasciatus* is also responsible for nocturnal anxiety and allergic responses because of its nuisance biting behaviour throughout the night, indoors and outdoors. During the day time, they remain mostly inactive and are mostly at rest in dark places like corners of rooms, and shelters. The nuisance biting normally affects most of the people rather than the transmission of diseases. Sometimes, biting of mosquitoes becomes more of nuisance and intolerable. Many new breeding habitats are created by human activities which become suitable for the breeding of other mosquitoes also. For the effective control of mosquitoes, it is very much essential to know about their behaviour [14,15]. In this context, the present work has been planned to make an attempt to study the biting behaviour of *Cx. quinquefasciatus* in an urban area. The study period was selected based on the prevalence of mosquitoes during rainy season. The study site is located in the middle of the city near Periyar bus stand surrounded by crowded streets and busy roads. Several stagnant pools could be seen with waste water and sewage adjacent to the railway track. This site is also near to the busy Madurai Junction. The location is crowded due to pilgrims visiting the temple and people visiting commercial complexes. The findings of the present study will be useful to the future researchers to reduce the biting problem and the transmission of mosquito-borne diseases.

Materials and Methods

Human beings are the major source of feed for many species of urban mosquitoes and therefore human landing collection provides valuable index of population density [16,17]. The biting behaviour of *Cx. quinquefasciatus* was studied in a house, located in Jaihindpuram, Madurai, Tamil Nadu, India (Figure 1). This area is known for the abundance of *Cx. quinquefasciatus*. Therefore this mosquito was selected in the present study to assess the biting behaviour. The landing mosquitoes for biting were collected during the period from July 2006 to November 2006 to assess the biting behaviour in four different sites. The collections

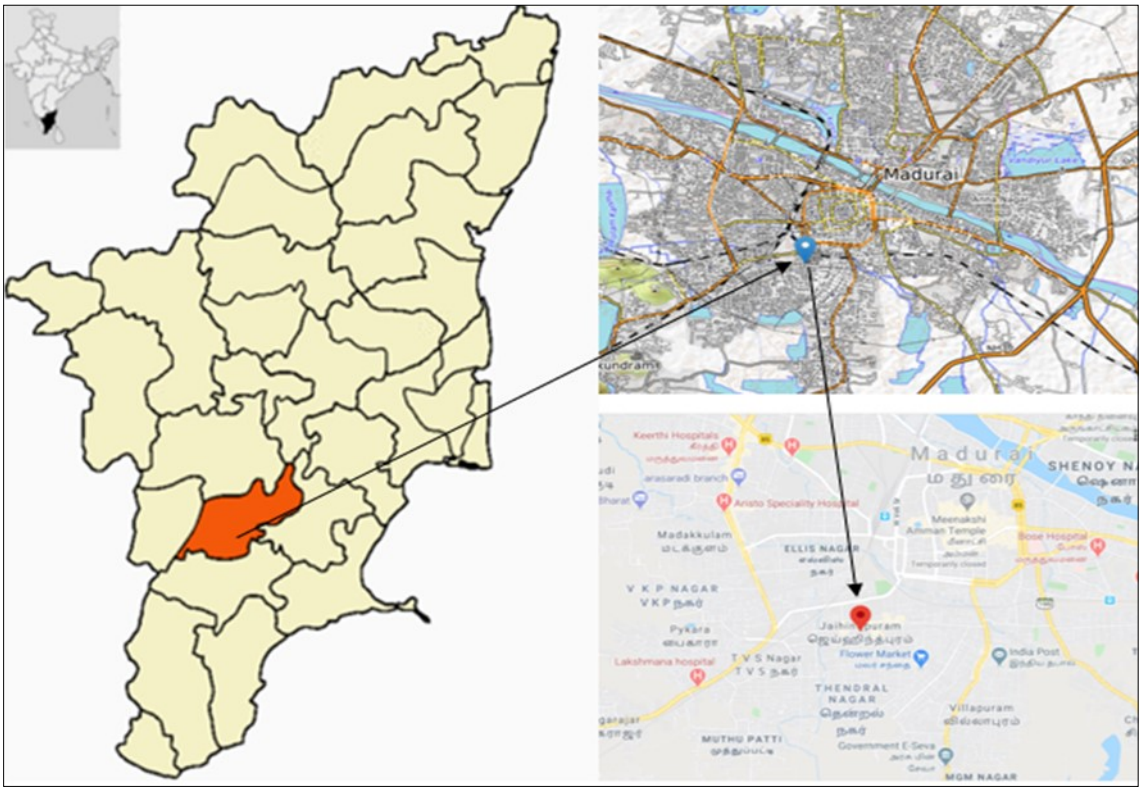


Figure 1. Map showing the selected study area in Jaihindpuram, Madurai, Tamil Nadu, India (Source: Google Maps)

were made in the first floor and second floor and also in the indoor and outdoor conditions. Adult mosquitoes attracted to human being (25 years old female) were collected from the collection sites for 24 hours continuously in order to determine whether *Cx. quinquefasciatus* exhibits exophagic or endophagic behaviour and also to note the existence of the vertical stratification in the biting behaviour. As per the methodology of Pandian and Chandrashekaran [18], the adult female mosquitoes landing on exposed parts of the leg for biting were collected with a small transparent plastic container with cap at the time of probing on the human beings. For catching of each mosquito, individual plastic container was used. Hourly collected mosquitoes were put in a separate labeled polythene bag. A mechanical aspirator was used to collect adult mosquitoes using flash lights during 18-06 hours. The collected specimens were brought to the laboratory and identified with standard keys [19,20,21]. After identification the hourly catches of mosquitoes were plotted to understand the biting pattern. As this mosquito species was dominant in numbers and the other species were negligible, this was alone considered. The data were collected twice and the mean values were calculated.

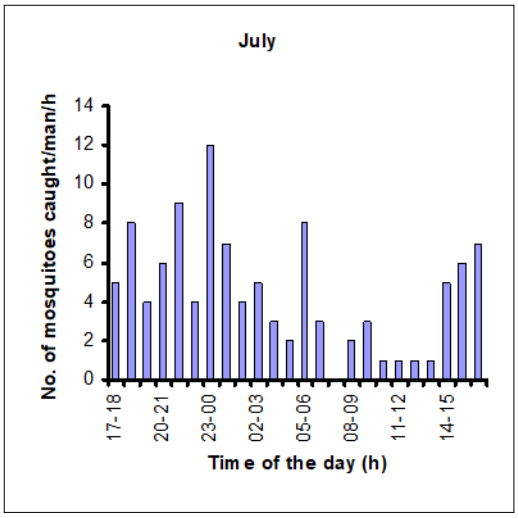
Results and Discussion

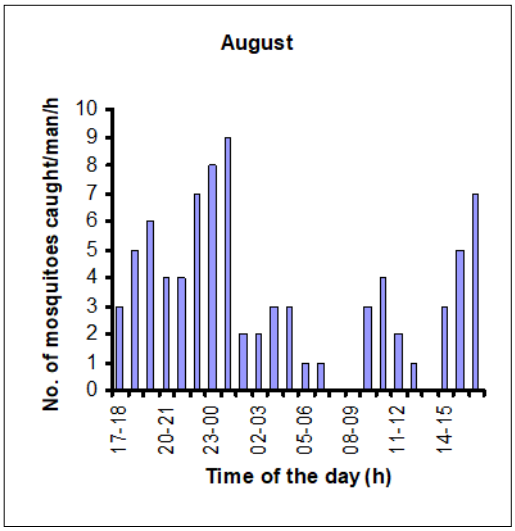
Mosquitoes are not only pests; they are also capable of transmitting several diseases like malaria, encephalitis and yellow fever. There are more than 2500 species of mosquitoes in the world. Recently, mosquito-borne diseases are threatening the world. Mosquitoes transmit diseases to more than 700,000,000 people each year. No single method will provide adequate control of mosquitoes and so a combination of biological, chemical and environmental management and repellents is needed at present to attack mosquitoes. In this context, the knowledge about the behaviour of mosquitoes and suggestion of suitable alternative methods are desirable. *Cx. quinquefasciatus* is found predominantly in the urban areas and it breeds enormously in all the available habitats and multiply in large numbers [22,23,24].

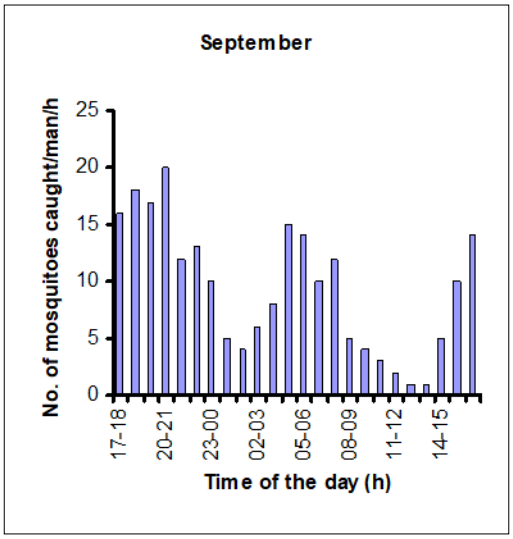
The identification of the pattern of biting rhythm of this mosquito is a pre-requisite for the testing of efficacy of both synthetic and plant derived repellents. This mosquito feeds mainly during the dark phase of the day. Though it feeds throughout the night, the peak of biting activity was recorded at three times, one soon after the dusk, another one at the middle of the night and the last one just before the dawn. The occurrence of multiple peaks in the biting activity is a unique feature. Peaks were noticed during 20-21 h during September and October while they were noticed during morning hours in August and November. Least values were observed during noon in all the six months (Figure 2).This mosquito exhibits exophagic behavior. Only in July the peak was seen in indoor conditions while in other other months peaks were observed in outdoor conditions. Maximum biting was noticed during 04-05 h in September, October and November (Figure 3, 4, 5, 6 and 7). This mosquito exhibited a vertical stratification in its biting behaviour by feeding predominantly in the first floor and to a lesser extent in the second floor. Biting was more in the first floor than that of second floor during the six months. Maximum biting was recorded during 20-21h in August, September and October. In July it was during 18-19h and 04-05h in November. *Cx. quinquefasciatus* revealed the nocturnal biting pattern in the present study, that means the biting activity was more in night time than the day time. Along with that, a mild biting activity was also observed in the early morning time. The predominant nocturnal biting pattern showed by *Cx. quinquefasciatus* in the study site correlated with the observations of Birley and Rajagopalan [25] and other similar kind of studies carried out at various time periods [26, 27,28, 29]. The mosquito showed a peak biting density between 18 and 20h in Nigeria which was demonstrated by the crowding of local people in outdoor till 22h in the study area [30].

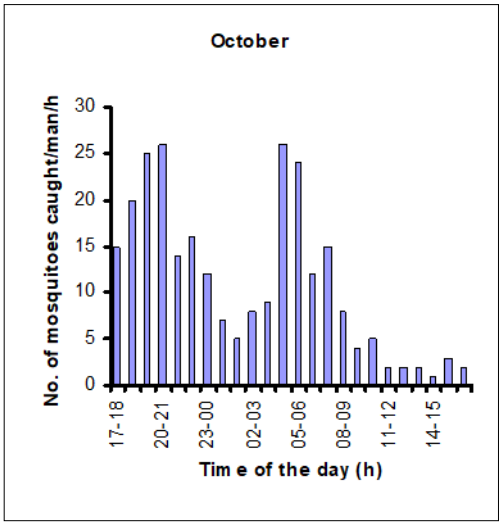
The temperature is always having inverse relationship with the population density of mosquitoes, whereas, rainfall is always having a positive relationship with the abundance of *Cx. quinquefasciatus*. This coincides with the findings of Lindsay et al. [31] and Gajanana et al. [32]. This is explicable as the rain creates more sites for mosquito breeding. The seasonal abundance of mosquitoes has been studied in several endemic areas including Pondicherry in India [33]. Other than climate and availability of breeding places, the factors like environmental conditions (odours from other sources, prohibitive wind speeds); physiological conditions (circadian phase, gonotrophic stage and nutritional status); and the mosquito genotype (olfactory proteins involved in response to external stimuli) are also having their influence on the population density. All these factors have been reported to affect the responsiveness of mosquitoes [34, 35]. For example, the vectors make use of human activities effectively for their breeding and perpetuation. The breeding habit of *Cx. quinquefasciatus* is an interesting phenomenon where they use to exploit the food processing activity of human beings in the Imo River Basin study areas, whose favorable food is fermented cassava, *Manihot utillissema*. In these areas, *Cx. quinquefasciatus* use the pots of fermenting cassava as their breeding site. This food processing strategy is practiced almost throughout the year and that ensures the breeding of *Cx. quinquefasciatus* all over the year. This kind of human practices alter the pattern of transmission of diseases in the tropics [36,37,38].

The establishment of insecticide resistance in major vectors reveals that single vector control operations are not suitable for the effective control of disease transmitting vectors in human beings. In this connection, the ideal one is integrated vector management that will permit the participation of individuals, communities and governments to understand the disease burden in the combination of a number of options available. Through that, people may ensure their safety against the prevalence of diseases [39]. The findings of this study revealed that different places of human dwelling elicited different responses which affected the behavioural landing site preference of *Cx. quinquefasciatus* in their attempt to feed on their host blood. The density of mosquitoes was abundant in the ground floor than the top floors and it exhibited a peak during midnight [40]. The vertical stratification of the mosquitoes was recorded. The density of mosquitoes was more in outdoor than indoor. It showed the exophilic behaviour in the feeding pattern. In the present study, there were several peaks of biting patterns observed i.e., one soon after the dusk, another one at the midnight and the last one just before the dawn. In conclusion, it is mandatory to take proper precautionary measures in order to protect humans from the dreadful mosquito-borne diseases and their









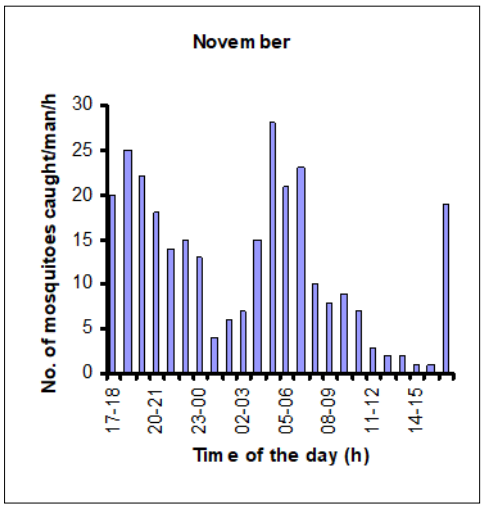
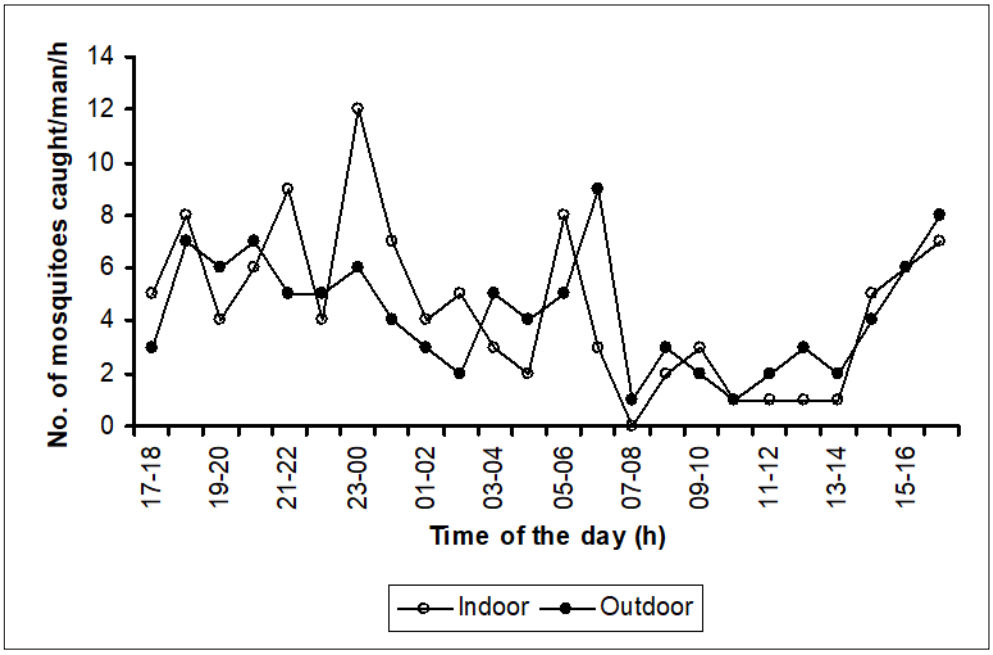


Figure 2. Biting pattern of mosquitoes collected from the study site during the period from July 2006 to November 2006



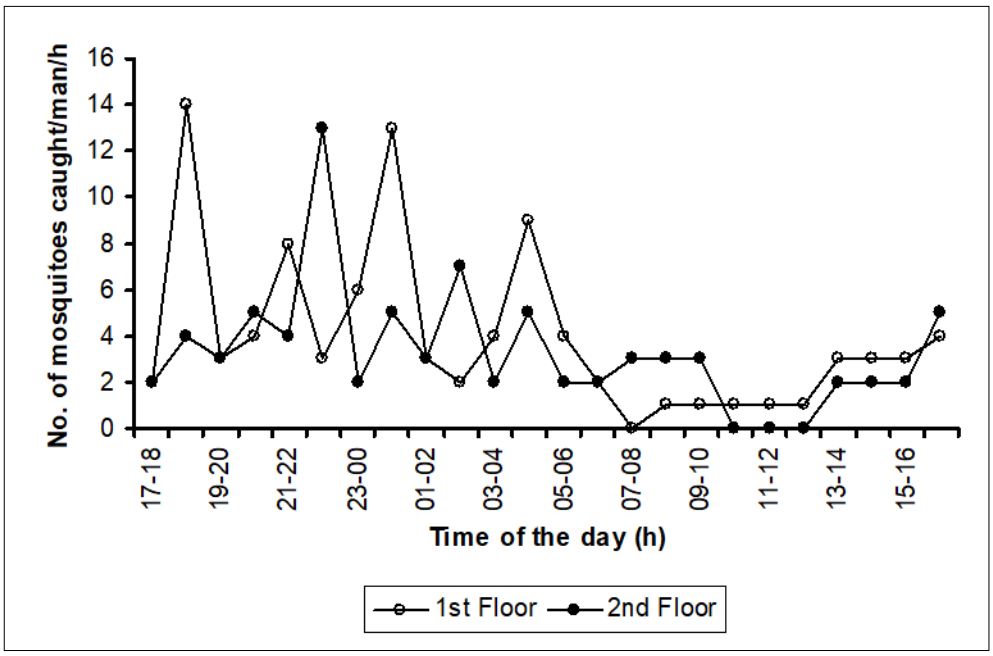
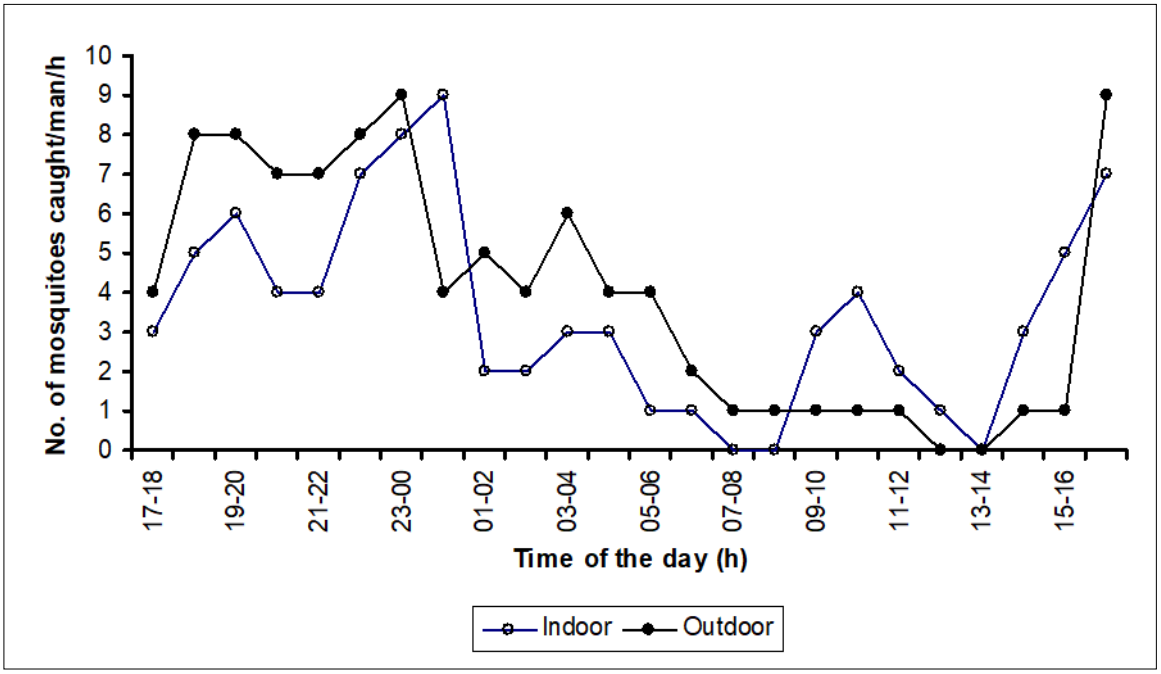


Figure 3. Number of mosquitoes collected from the four different sites in July 2006 during the study period



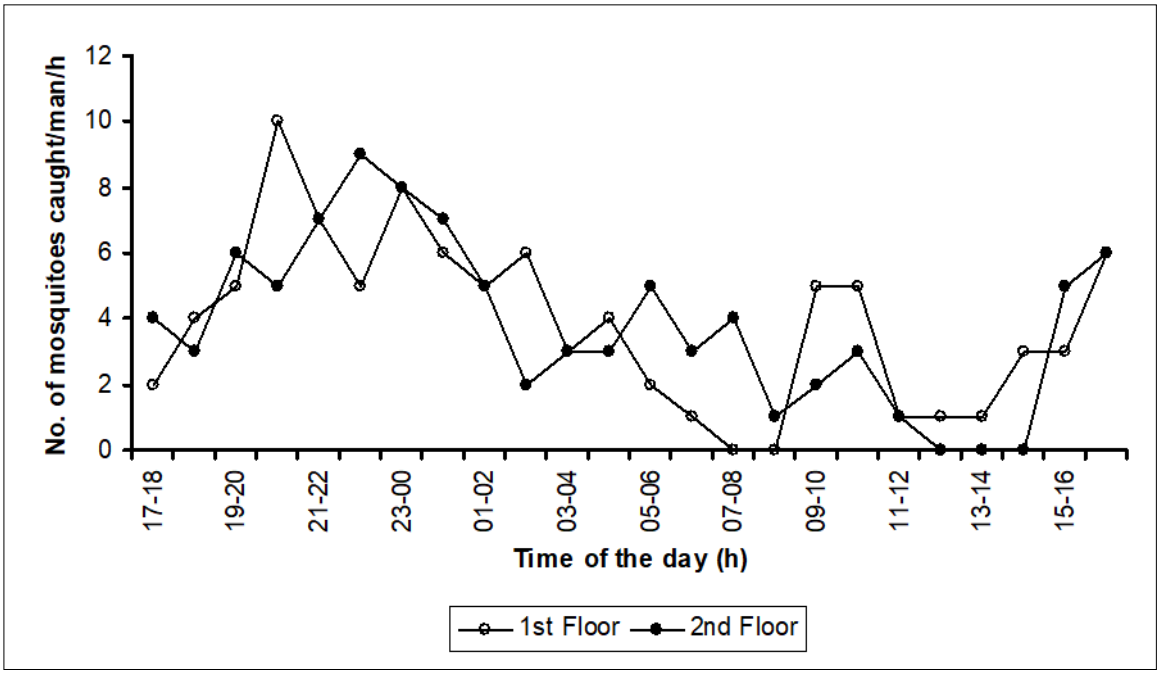
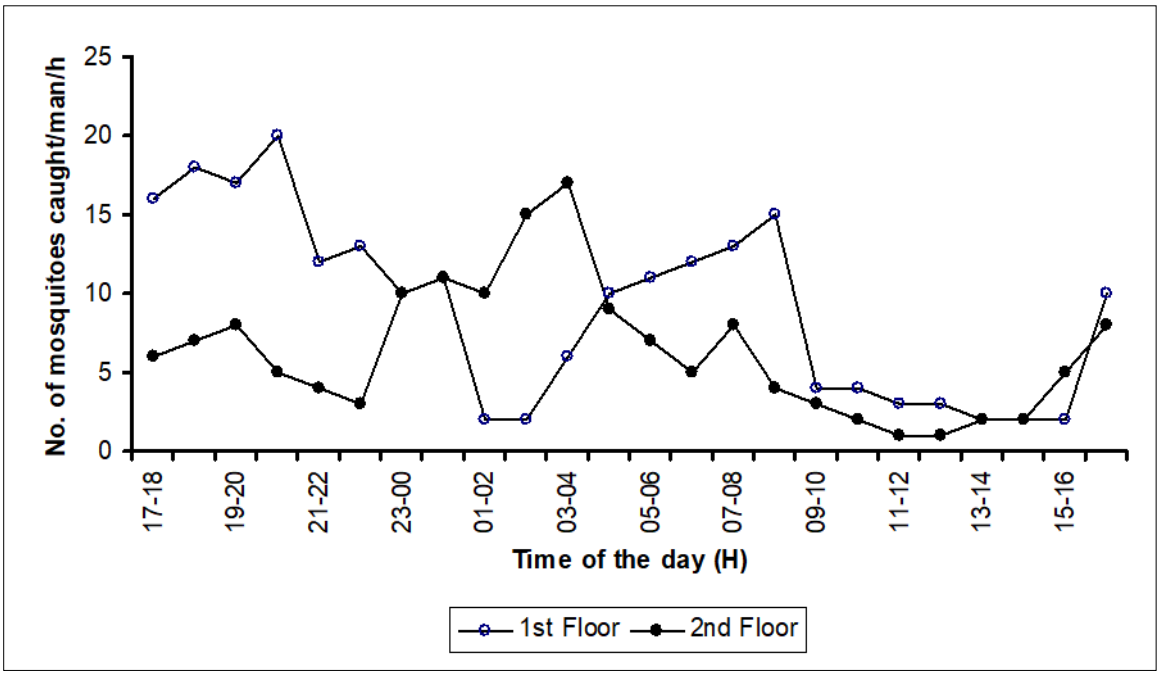


Figure 4. Number of mosquitoes collected from the four different sites in August 2006 during the study period



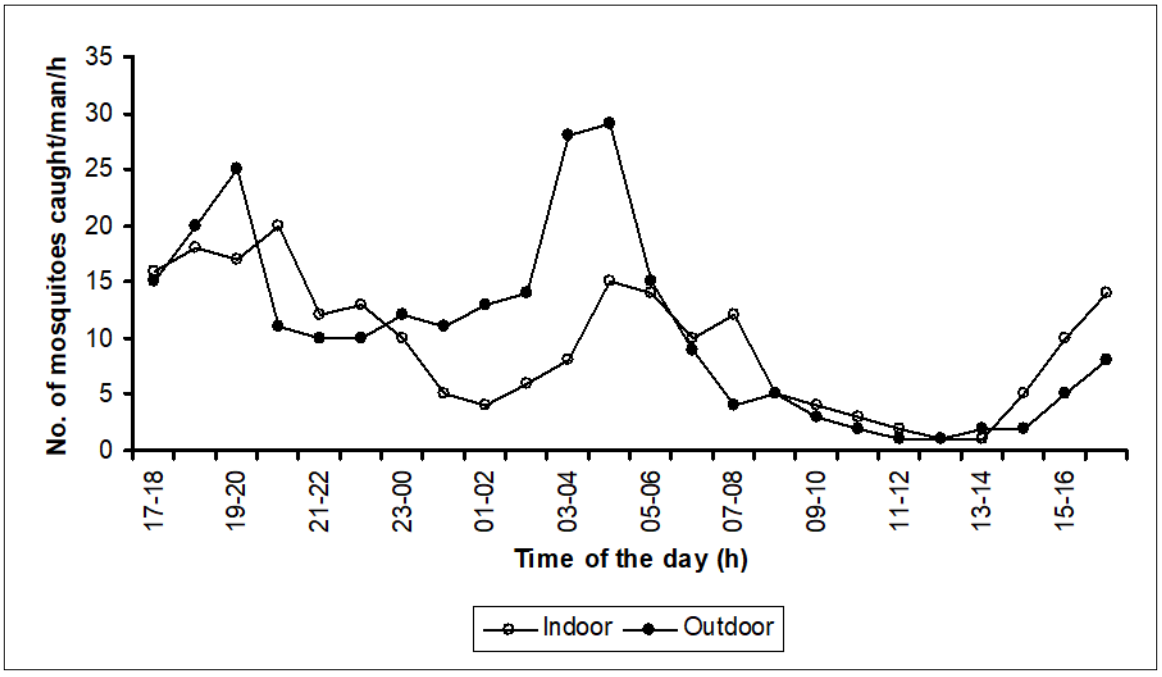
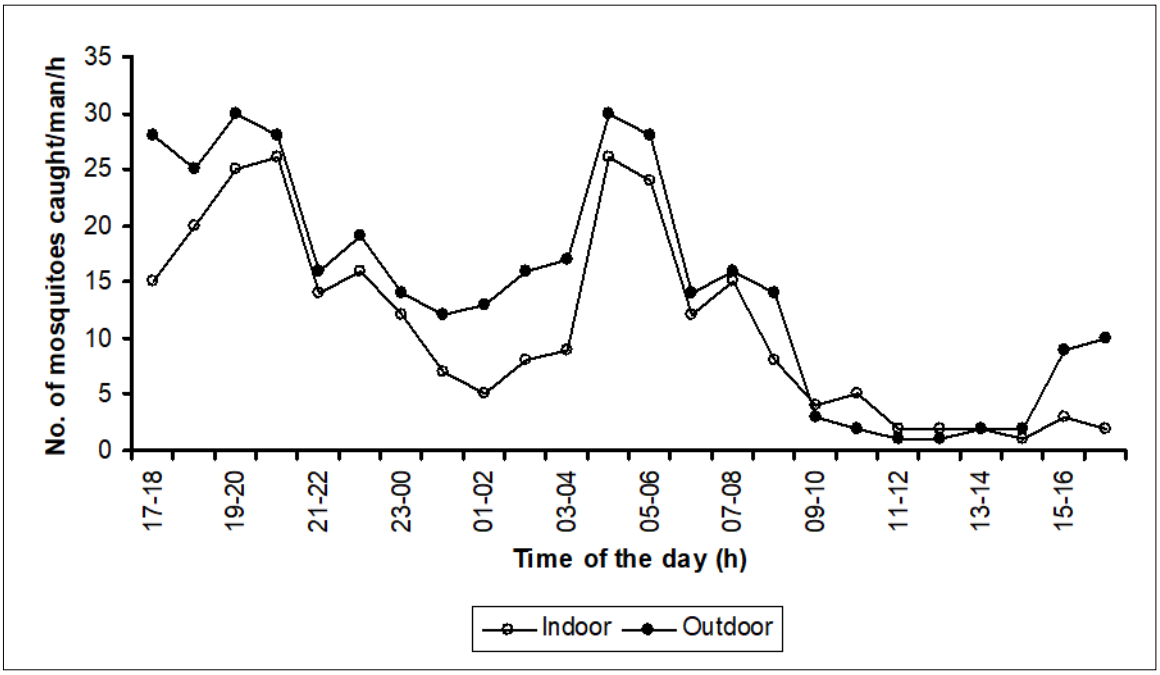


Figure 5. Number of mosquitoes collected from the four different sites in September 2006 during the study period



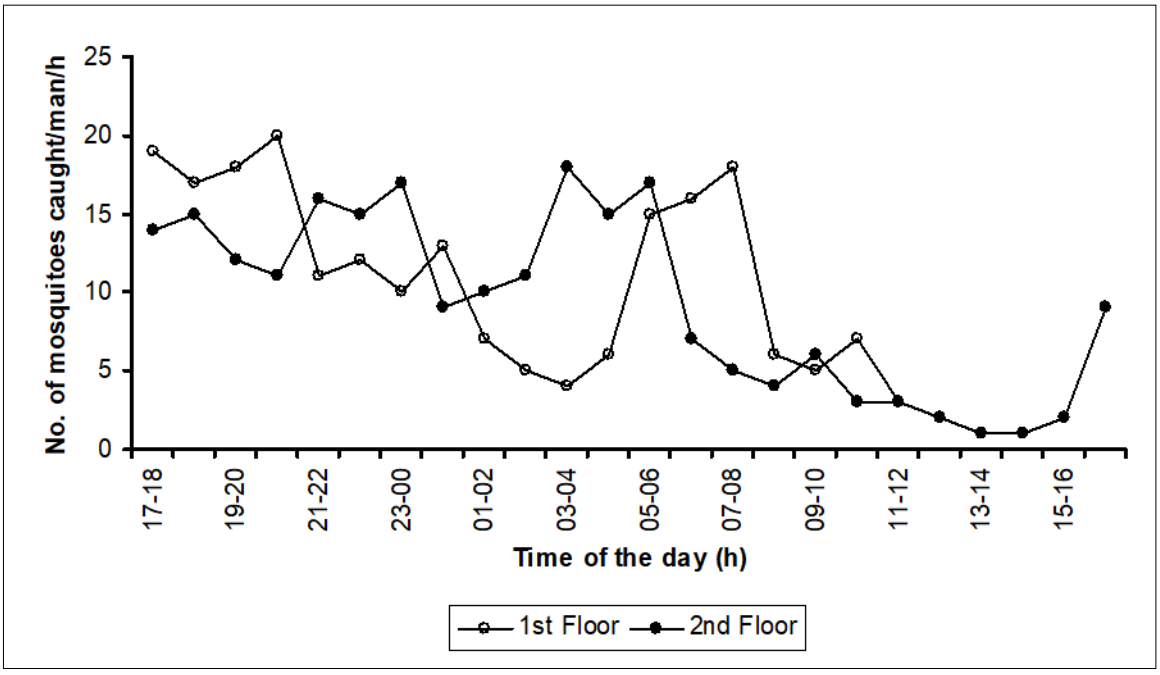


Figure 6. Number of mosquitoes collected from the four different sites in October 2006 during the study period

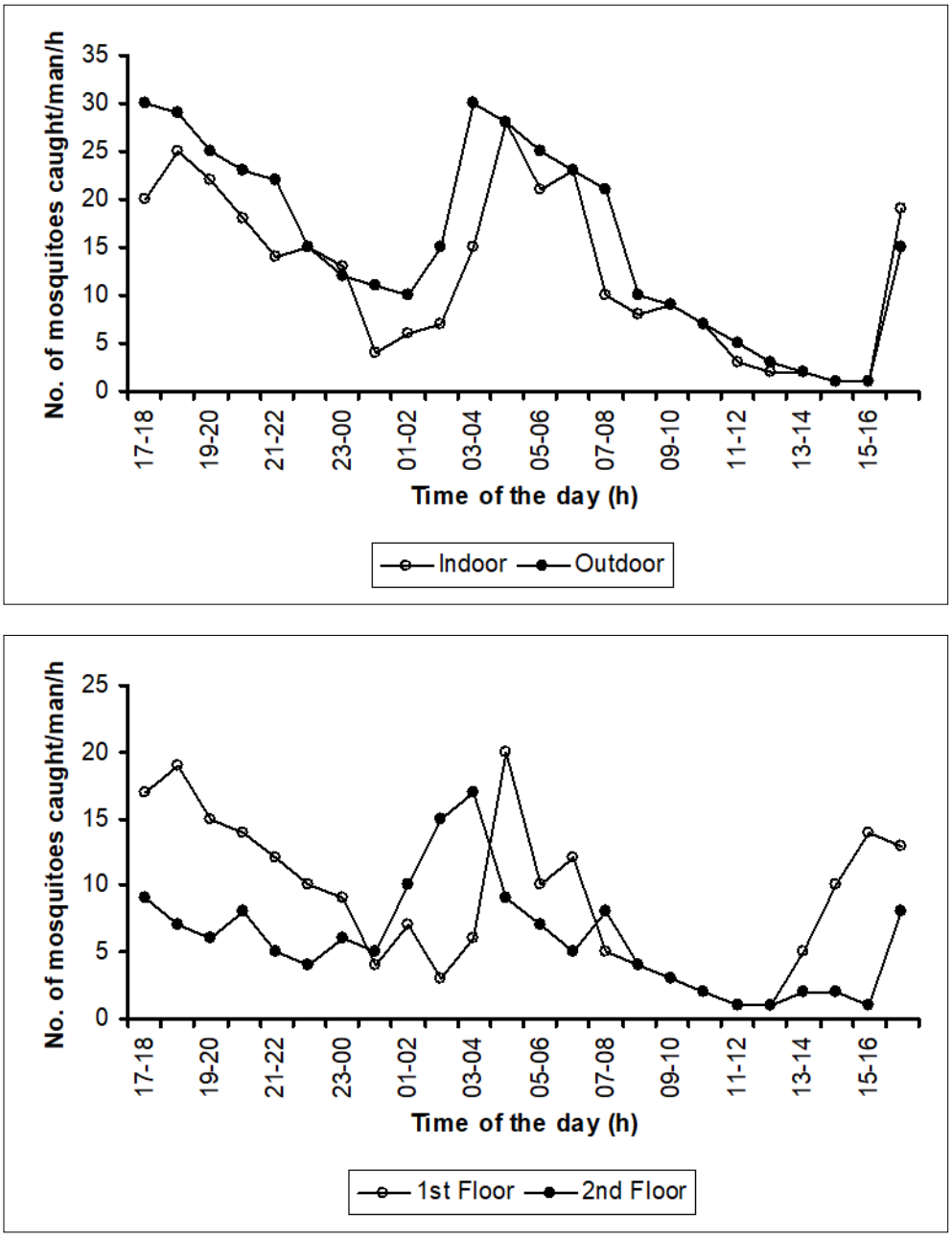


Figure 7. Number of mosquitoes collected from the four different sites in November 2006 during the study period

nuisance. Hence it is recommended to avoid the mosquito bites by avoiding infested areas, wearing protective cloth and applying appropriate mosquito repellents in order to safeguard from the mosquitoes and their ill effects.

Conclusion

The vector population was more in outdoor than that of indoor conditions and more in ground floor than that of first and second floors. They exhibited exophilic pattern and three peaks of biting behavior.

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References

1. Williams SJ (2000). Mosquitoes mankind's enemy. In: *Proceedings of the international symposium on recent trends in combating mosquitoes, Chennai, India*. 1-9.
2. Rueda LM (2007). Global diversity of mosquitoes (Insecta: Diptera: Culicidae) in freshwater. In: *Freshwater animal diversity assessment*. Springer, Dordrecht. pp. 477-487.
3. Kline DL (2007). Mosquitoes: Biology. *Pimentel D. Encyclopedia of Pest Management*, 2: 350-359.
4. Manguin S, Boëte C (2011). Global impact of mosquito biodiversity, human vector-borne diseases and environmental change. *The importance of biological interactions in the study of biodiversity*, 27-50.
5. Naseem S, Malik MF, Munir T (2016). Mosquito management: A review. *Journal of Entomology and Zoology Studies*, 4(5), 73-79.
6. McMichael AJ (2000). The urban environment and health in a world of increasing globalization: issues for developing countries. *Bulletin of the world Health Organization*, 78: 1117-1126.
7. Tolle, MA (2009). Mosquito-borne diseases. *Current problems in pediatric and adolescent health care*, 39 (4): 97-140.
8. Chaves LF, Hamer GL, Walker ED, Brown WM, Ruiz MO et al. (2011). Climatic variability and landscape heterogeneity impact urban mosquito diversity and vector abundance and infection. *Ecosphere*, 2(6): 1-21.
9. Dame DA, Curtis CF, Benedict MQ, Robinson AS, Knols BG (2009). Historical applications of induced sterilisation in field populations of mosquitoes. *Malaria Journal*, 8(2): 12-18.
10. Bhattacharya S, Basu P, Sajal BC (2016). The southern house mosquito, *Culex quinquefasciatus*: profile of a smart vector. *J. Entomol. Zool. Stud.*, 4 (2): 73-81.
11. Seda J, Horrall S (2019). Mosquito Bites. In: *StatPearls [Internet]*. StatPearls Publishing.
12. David MR, Ribeiro GS, de Freitas RM (2012). Bionomics of *Culex quinquefasciatus* within urban areas of Rio de Janeiro, Southeastern Brazil, *Revista de Sa´ude P´ublica*, 46 (5): 858–865.
13. Reisen WK, Lothrop HD, Lothrop B (2003). Factors influencing the outcome of mark-release-recapture studies with *Culex tarsalis* (Diptera: Culicidae), *Journal of Medical Entomology*, 40 (6): 820–829.
14. Jones CE, Lounibos LP, Marra PP, Kilpatrick AM (2012). Rainfall influences survival of Culex pipiens (Diptera: Culicidae) in a residential neighborhood in the mid-atlantic United States, *Journal of Medical Entomology*, 49 (3): 467–473.
15. de Souza DK, Koudou B, Kelly-Hope LA, Wilson MD, Bockarie MJ et al. (2012). Diversity and transmission competence in lymphatic filariasis vectors in West Africa, and the implications for accelerated elimination of *Anopheles* transmitted filariasis. *Parasites & Vectors*, 5: 259-267.
16. Pandian RS (1997). Habitat selection by the urban and suburban mosquitoes. *J. Env. Poll.,* 1: 45-47.
17. Pandian RS, Manoharan, AC (1996). Effect of environment on the biodiversity pattern of mosquito fauna in the urban rural areas. *Insect Environment,* 1: 4-8.
18. Pandian RS, Chandrashekaran MK (1980). Rhythms in the biting behaviour of mosquito *Armigeres subalbatus*. Oecologia (Berl.), 47: 89-95.
19. Christopher SR (1933). The fauna of British India, including Celon and Burma. Diptera. Volume IV. Family Culicidae. Tribe Anophelini London: Taylor and Francis.

20. Barraud PJ (1934). The fauna of British India including Ceylon and Burma. Diptera. Volume V. Family Culicidae. Tribes Megarhinini and Culicini in Salinas, Puerto Rico. *Journal of Medical Entomology*, 43: 484 -492.

21. Reuben R, Tewari SC, Hiriyan J, Akiyama J (1994). Illustrated keys to species of *Culex* (Culex) associated with Japanese encephalitis in Southeast Asia (Diptera: Culicidae). *Mosquito Systematic Journal*. 26: 76-96.

22. Karisa J, Muriu S, Omuoyo D, Karia B, Nyamwaya D et al. (2019). Urban ecology of arboviral mosquito vectors along the Kenyan coast. *BioRxiv*, 593350.

23. Goddard J (2018). Mosquito-borne diseases. In: *Infectious Diseases and Arthropods*. Humana Press, Cham. Pp. 39-89.

24. Dev V, Sharma VP, Barman K (2015). Mosquito-borne diseases in Assam, north-east India: current status and key challenges. *WHO South-East Asia Journal of Public Health*, 4(1): 20-29.

25. Birley MH, Rajagopalan PK (1981). Estimation of the survival and biting rates of *Culex quinquefasciatus* (Diptera: Culicidae). *Journal of Medical Entomology*. 18(3): 181-186.

26. Pandian RS, Manoharan AC (1994). Survey on the mosquitoes of Avaniyapuram, a sewage fodder farm area of Madurai Corporation in Tamil Nadu, India. Geobios New Reports, 13: 109–113.

27. Bhattacharya DR, Dutta SA, Khan P, Doloi G, Goswami BK (1995). Biting cycles of some potential vector mosquitoes of Japanese encephalitis of Assam, India. *Southeast Asian J. Tropical Medicine and Public Health,* 26: 177-179.

28. Mani TR, Rao CV, Rajendran R, Devaputra M, Prasanna Y, Hanumaiah S et al. (1991). Surveillance for Japanese encephalitis in villages near Madurai, Tamil Nadu, India. Transactions of the Royal Society of Tropical Medicine and Hygiene, 85(2): 287-291.

29. Rohani A, Zamree I, Mohamad WNW, Abdul Hadi A, Asmad M (2013).Nocturnal man biting habits of mosquito species in Serian, Sarawak, Malaysia. *Advances in Entomology*, 1(2): 42-49.

30. Emmanuel CU, Gloria NW, Christiana O (2013). The Abundance and Biting Patterns of *Culex quinquefasciatus* Say (Culicidae) in the Coastal Region of Nigeria ISRN Zoology, 640691:7.

31. Lindsay SW, Shenton FC, Snow RW, Greenwood BM (1989). Responses of Anopheles gambiae complex mosquitoes to the use of untreated bed nets in Gambia. *Medical and Veterinary Entomology*, 3 (3): 253–262.

32. Gajanana R, Rajendran PP, Samuel G (1997). Japanese encephalitis in South Arcot district, Tamil Nadu, India: a three year longitudinal study of vector abundance and infection frequency. *Journal of Medical Entomology*, 34(6): 651–659.

33. Ramaiah KD, Das PK (1992). Seasonality of adult *Culex quinquefasciatus* and transmission of bancroftian filariasis in pondicherry, South India. *Acta Tropica,* 50(4): 275–283.

34. Nwoke BEB, Nduka FO, Okereke OM, Ehighibe OC (1993). Sustainable urban development and human health: septic tank as a major breeding habitat of mosquito vectors of human diseases in south-eastern Nigeria. *Applied Parasitology*, 34(1): 1-10.

35. Costantini C, Sagnon NF, della Torre A, Diallo M, Brady J, et al. (1998). Odour-mediated host preferences of West African mosquitoes, with particular reference to malaria vectors. *Am. J. Trop. Med. Hyg.,* 58: 56–63.

36. Tylleskar T, Banea M, Bikangi N, Cooke RK, Poulter NH, et al, (1992). Cassava cyanogens and konzo, an upper motoneuron disease found in Africa. *The Lancet*, 339 (8787): 208–211.

37. Uttah EC, Simonsen PE, Pedersen EM, Udonsi JK (2005). Public health dimensions of Cassava processing in Eastern Nigeria. *International Journal of Social Sciences*, 4(1): 22–33.

38. Iwuala MOE (1979). Cassava fermentation pools as major breeding foci for culicine mosquitoes in Nsukka Nigeria. *The Nigerian Medical Journal*, 9(3): 327–335.

39. Oduola AO, Awe O (2006). Behavioural biting preference of *Culex quinquefasciatus* in human host in Lagos metropolis Nigeria. *Journal of Vector Borne Diseases*, 43(1): pp. 16–20.

40. Pandian RS, Roy RES (2001). Interspecific variation in the feeding behaviour of urban mosquitoes, *Culex quinquefasciatus* Say in the diurnal cycle. *Insect Environment,* 7 (3): 119-120.