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Biting rhythm of vector mosquitoes in a rural ecosystem of south India

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Abstract
Mosquitoes transmit a variety of pathogens to man and understanding its biting periodicity helps to reduce the man-vector contact, which is a crucial factor for pathogen transmission. An in-depth field study was undertaken to determine the biting pattern and the biting rhythm of vector mosquitoes in the rural areas of Sivaganga district, Tamil Nadu, south India during 2006-2008. Three types of rhythmic biting patterns namely; nocturnal, diurnal and crepuscular were observed in the study area and a few species of mosquitoes found exhibited a restricted pattern of biting behavior. Moreover, it was found that a temporal variation in the biting pattern of mosquitoes and the adaptive feature of avoiding competition among themselves by sharing the available vertebrate hosts in the rural areas during the different periods in the diel cycle, which is very important for implementing vector control strategies to prevent man – vector contact for the prevention of vector borne diseases.

Keywords: Feeding behavior, Biting rhythm, Crepuscular, Nocturnal, Diurnal biting rhythm.

1. Introduction

Global warming has severe impacts on the emergence of public health important vector borne diseases [13]. Vector borne pathogens transmission to man is primarily determined by the feeding behavior of hematophagous arthropods [20]. Mosquitoes are the nuisance pests as well as involve in the transmission of various public health important vector borne parasites which cause diseases such as malaria, filariasis, Japanese encephalitis, dengue, Chikungunya and so on [1,25,9]. Feeding behaviour of the mosquitoes are considered to be the important factor which facilitates the man – vector contact and thereby leading to the transmission of vector borne diseases. Mosquitoes exhibit host preference behavior as well as typical rhythmic pattern in their biting behavior [5]. The difference in the feeding pattern contributes significantly in the transmission pattern of diseases among various hosts during different seasons. The rapid change in the ecosystem due to several factors such as the increase in global warming [7], unplanned urbanization, deforestation, changing human behavior [29], availability of hosts [10] are found affecting the behavior of mosquitoes and thereby enhancing vector borne pathogen's transmission. The present study reports the biting behaviour of vector mosquitoes that are prevailing in the rural areas in Tiruppuvanam Block, Sivaganga district of Tamil Nadu, south India.

2. Study area

Tiruppuvanam (Longitude N 09^0 : 49.341' and Latitude E 078^0 : 15. 831'), a selection grade town panchayat in Sivaganga district, Tamil Nadu, India has been selected for the study. It is geographically situated at a distance of 18 Km away from Madurai on road (National Highway- NH 49) towards Rameshwaram, a pilgrimage centre. In the recent past there has been rapid urbanization taken place in this area by converting the agro-ecosystem to semi-urban areas. Hence, in the Tiruppuvanam panchayat, eighteen villages from the Tiruppuvanam block were randomly selected for the study (Fig.1).

Tiruppuvanam is located on the bank of river Vaigai. The block includes villages with a variety of geographical landscapes viz. plain landscapes, fertile lands and water bodies. The study area receives water for irrigation from Vaigai river, rain water stored in major and minor tanks, ground water through pump sets. The Block has different pattern of human settlements such as pucca concrete houses, thatched roof houses and huts. Cattle sheds and chicken roosting sites are located near the human settlements in the study area. During 1987, JE cases had been reported to be occured in Thanjakoor village near Tirupuvanam area in Sivagangai district in Tamil Nadu [21]. Moreover, frequent dengue and Chikungunya cases have also been recorded during 2006-2007 [27]. In addition cases of malaria have also been seen in these areas, though it has been reported to be in laborers migrated from the endemic area Rameshwaram, Tamil Nadu [26]. Hence, attempts were undertaken to understand the biting rhythm of different vector mosquitoes and the present communication reports the results of the biting behavior of the mosquito species prevalent in the study area.

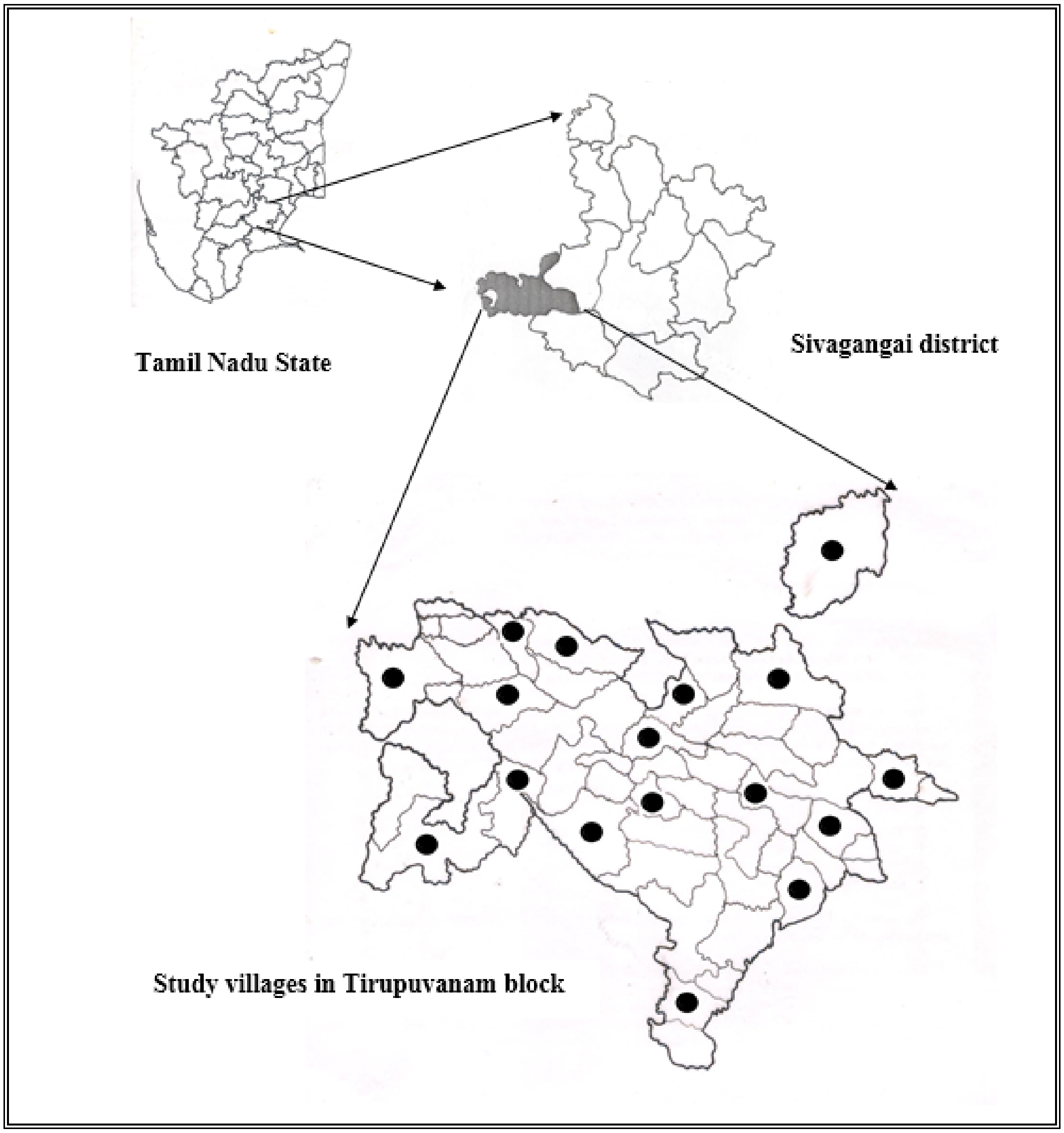

Fig 1: Map showing the selected study villages in Thirupuvanam block, Sivagangai District, Tamil Nadu state

3. Materials and Methods

The survey was carried out for two years in the study area during 2006-2008. To determine the biting rhythm of mosquito species, adult mosquitoes attracted to human in outdoors were collected from study sites for a period of 24 hours continuously. 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 humans as per the methodology described by Pandian and Chandrashekaran (1980) [22]. Individual plastic container was used for catching each mosquito. Hourly collected mosquitoes were labeled and put in a separate labelled polythene bag. A mechanical aspirator was used to collect adult mosquitoes using flash lights during 18-6 hours. The collected specimens were brought to the laboratory and identified with standard identification keys [8, 2, 30]. After identification the hourly catches of mosquitoes were plotted to understand the biting pattern such as rhythmic or arrhythmic. Mid-point value of biting for each mosquito species was calculated to compare the rhythmic biting pattern in the diel cycle.

4. Results and Discussion

A total of 20 mosquito species including 7 important vector mosquitoes namely *Culex tritaeniorhynchus, Cx. pseudovishnui, Cx. vishnui, Cx. quinquefasciatus, Aedes aegypti, Ae. albopictus,* and *Cx. gelidus* were recorded during the study (Table.1). The recorded mosquitoes exhibited either rhythmic or arrhythmic. If it is rhythmic, it may be either diurnal or nocturnal or crepuscular. The results have clearly indicated a temporal variation in the biting pattern of mosquitoes studied (Figure. 2 & 3). Three types of biting patterns, namely diurnal, nocturnal and crepuscular were observed and in addition a restricted pattern of biting periodicity was also recorded among four mosquito species during the study period. Thirteen species namely *Ae. caecus, Ae. vexans vexans, Ae. vittatus, Anopheles barbirostris, An. hyrcanus group-s, An. subpictus, An. vagus, Culex gelidus, Cx. infula, Cx. pseudovishnui, Cx. quinquefasciatus, Cx. tritaeniorhynchus* and *Cx. vishnui* exhibited nocturnal pattern of biting rhythm.

Table 1: Biting pattern and mid-point values of biting rhythm of mosquitoes in the study area

Sl. No	Species	Rhythmic pattern			Restricted pattern	Mid-pont value (h)
		Nocturnal	Diurnal	Crepuscular		
1	***Aedes aegypti***	-	+	-	-	10^{40}
2	***Aedes albopictus***	-	+	-	-	11^{30}
3	***Aedes caecus***	+	-	-	-	20^{30}
4	***Aedes pallidostriatus***	-	-	-	+	18^{30}
5	***Aedes vexans vexans***	+	-	-	-	18^{53}
6	***Aedes vittatus***	+	-	-	-	20^{20}
7	***Armigeres subalbatus***	-	-	+	-	20^{20}
8	***Anopheles barbirostris***	+	-	-	-	24^{30}
9	***Anopheles hyrcanus***	+	-	-	-	22^{08}
10	***Anopheles pallidus***	-	-	-	+	18^{40}
11	***Anopheles subpictus***	+	-	-	-	19^{50}
12	***Anopheles tessellatus***	-	-	-	+	19^{30}
13	***Anopheles vagus***	+	-	-	-	23^{00}
14	***Culex bitaeniorhynchus***	-	-	-	+	19^{30}
15	***Culex gelidus***	+	-	-	-	20^{24}
16	***Culex infula***	+	-	-	-	22^{58}
17	***Culex pseudovishnui***	+	-	-	-	20^{24}
18	***Culex quinquefasciatus***	+	-	-	-	23^{14}
19	***Culex tritaeniorhynchus***	+	-	-	-	21^{57}
20	***Culex vishnui***	+	-	-	-	22^{23}

+ = presence
- = absence

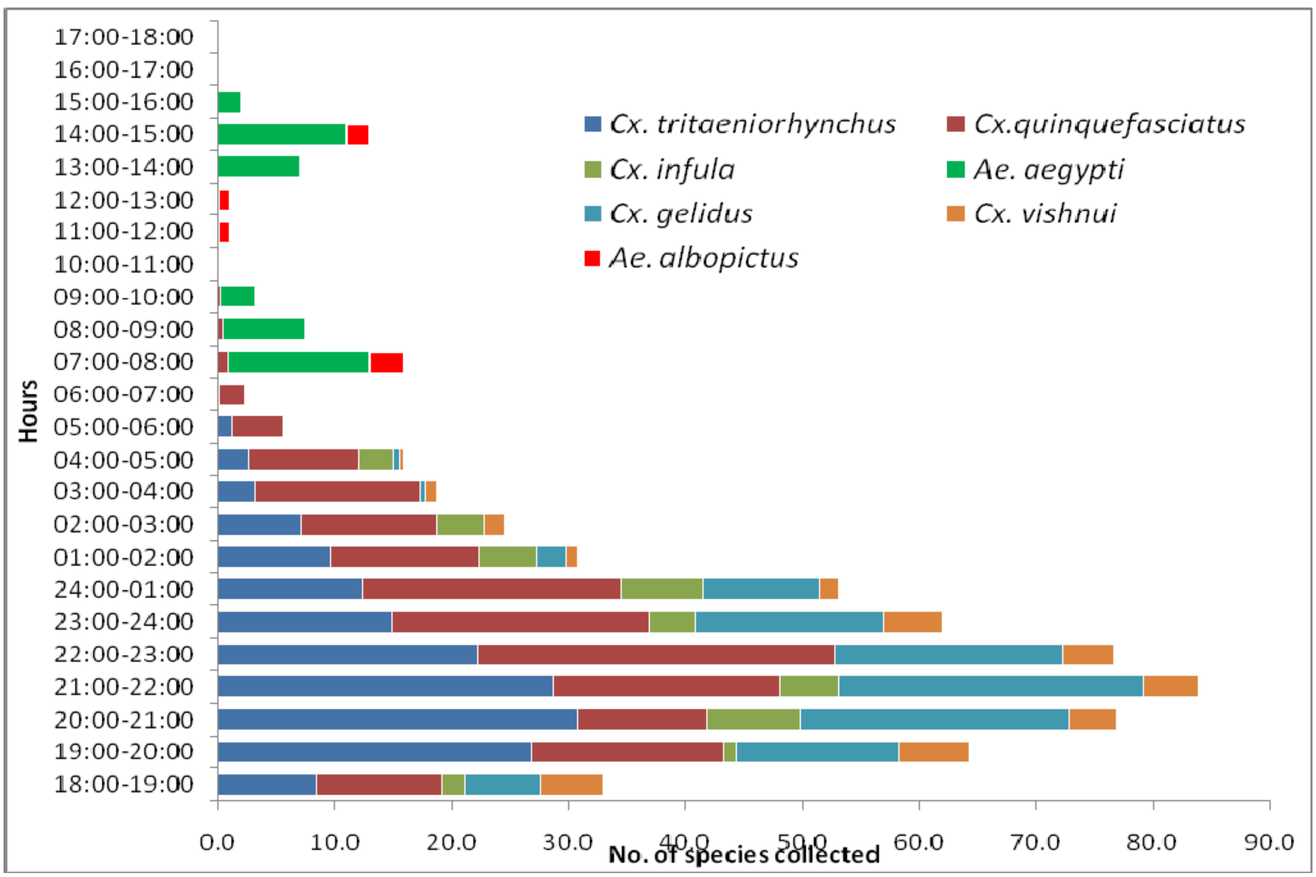

Fig 2: Consolidated picture of biting rhythm of mosquitoes collected from Thirupuvanam block, Sivagangai district, Tamil Nadu

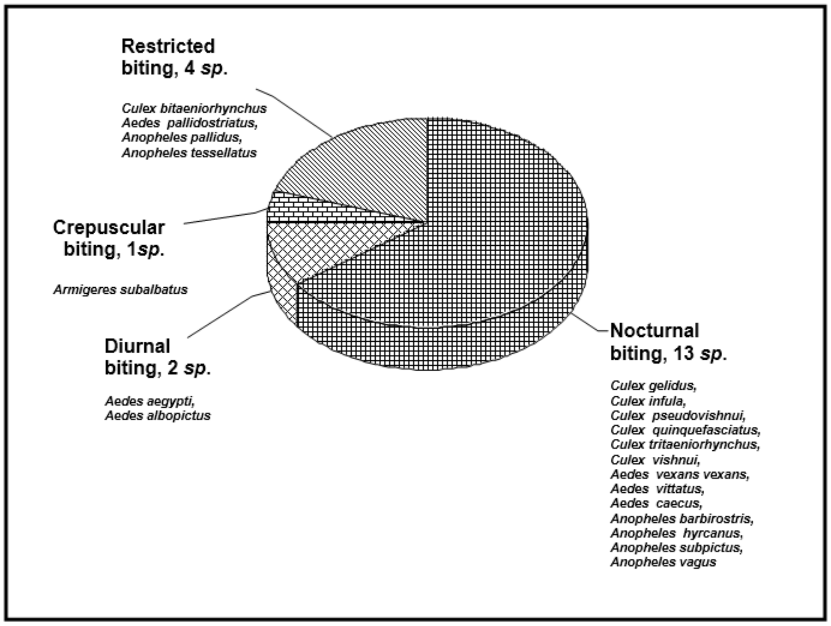

Fig 3: Pie chart showing the biting pattern of mosquitoes recorded in the study area

Culex quinquefasciatus (the vector of human lymphatic filariasis) exhibited a nocturnal biting pattern, which biting continued throughout mid-night and showed a declining trend after mid-night peak. In addition, a mild biting activity was also observed in the early morning time (Fig.4). The nocturnal biting pattern exhibited by *Cx. quinquefasciatus* in the study area correlated with the findings of Birley and Rajagopalan (1981) [4]; Pandian and Manoharan (1994) [24]. The exhibition of predominant nocturnal biting rhythm of all the *Culex* spp in the study area were found similar to the results of various studies conducted elsewhere [3]. On the other hand, the mosquito exhibited a peak biting density between 1800 and 2000 hours outdoor in Nigeria [11] which was explained by the accumulation of local people stayed outdoor till 22:00 hours in the study area.

Culex tritaeniorhynchus (the principal vector of Japanese encephalitis) showed a typical nocturnal biting pattern and the biting rhythm reached a peak at mid-night. After mid-night peak, the decrease in the density of biting mosquitoes was observed up-to dawn (Fig.5). Though the results of the present study have coincided with the observation of earlier studies conducted [31, 16], a Malaysian study recorded three peaks of biting activity of *Cx.tritaeniorhynchus* [34]. This mosquito is an exophilic and strongly attracted towards Cattle to 88-95% [37]. *Cx. gelidus*, a zoophilic mosquito, exhibited nocturnal biting pattern with a prominent post dusk peak of activity. The biting activity was restricted during the early part of the night, *i.e.*, before mid-night (Fig.6). But, its biting activity has also been observed throughout night with a peak biting between 0300 and 0600 hours [36]. A typical nocturnal uniform biting activity was exhibited by *Cx. infula* and the biting was restricted uniformly during the dark phase (Fig.7). *Cx. vishnui* and *Cx.pseudovishnui* showed a nocturnal biting rhythm and showed a post dusk biting peak like *Cx. gelidus* (Fig.8 & Fig.9).

Anopheles hyrcanus group exhibited a typical nocturnal biting pattern followed by the appearance of a sharp peak in the pre-mid-night period. After mid-night, the rate of biting was reduced (Fig.10). Presence of nocturnal biting activity with the appearance of a major peak during post dusk phase was shown by *An. subpictus* mosquitoes, which has been proposed to be to play secondary role in zoonotic transmission of virus infections (Fig.11). A minor biting peak was also noticed during pre-dawn period. Similarly, host seeking behavior of certain malarial vector mosquito species were found to reach a peak between 2-3 AM in Accra, Ghana [18].

While studying the biting rhythm of other Anopheline species, *An. barbirostirs* showed a typical nocturnal biting pattern with two peaks of activity; one major biting peak during the mid-night and another minor peak during pre-dawn period (Fig.12). *Anopheles vagus* exhibited nocturnal biting activity and the maximum biting activity was seen during the mid-night hours (Fig.13). However, while studying the biting behavior of *An. oswaldoi* in the Amazon region of Columbia, Rodríguez *et al.*, (2009) [33] observed the dropping of biting rate steadily from a peak of >15 bites/person-night at the start of the night (1800-1900 hours) to approximately equal to 2 bites/person-night before dawn. The earlier reports documents the predominant crepuscular biting behavior of Anopheline mosquitoes [17, 35]. Moreover, inter-population variation in biting pattern of *An. darlingi* has been shown to be as important as the intra-population variation [15]. Outdoor host seeking behavior of *An. gambiae* was reported in Bioro Islands [28].

Aedes vexans (Fig.14) and *Ae. vittatus* (Fig.15) showed a nocturnal biting activity with the post-dawn peak and these mosquitoes exhibited a restricted nocturnal biting pattern. The high attraction of *Ae. vexan* towards man in the rural area is noticed in the study area, which contradicts the observation of Gingrich and Williams (2005) [12], where the species was found poorly attracted to man. *Aedes albopictus* (the vector of dengue and Chikungunya), showed a scattered diurnal biting activity mainly during morning and evening hours (Fig.16). The anthropophilic feeding behavior of *Ae. albopictus* has been well documented [14 & 32]. *Aedes aegypti,* the primary vector of dengue and Chikungunya fever, breeds in clean water [23] exhibited, a typical diurnal pattern with two peaks of activity, one in the forenoon and another one in the afternoon (Fig.17). Typical diurnal biting rhythm of *Ae. aegypti* and *Ae. albopictus* supported the earlier report [6]. The interesting findings of the recent reports described a heterogeneous blood feeding pattern of *Ae. aegypti*, which is epidemiologically significant in transmission and controlling dengue [19].

Armigeres subalbatus showed a typical crepuscular biting pattern with a major peak during the dusk period, which was slightly extended upto mid-night. A minor biting peak was observed during dawn period (Fig.18) which coincide with the findings of Pandian and Chandrashekaran (1980) [22].

Though the high anthrophilic feeding behavior of *Ae. aegypti*, *Ae. albopictus* and *Cx.quinquefasciatus* has been well documented, the highly zoophilic *Cx. gelidus*, *Cx. vishnui*, *Cx. pseudovishnui* and *Cx.tritaeniorhynchus* mosquitoes [31] are also attracted towards man indicate the possible risk of transmitting zoonotic infections to human if the reservoir host of the pathogens enter the rural areas.

A restricted biting pattern was recorded in *Cx. bitaeniorhynchus*, *Ae. pallidostriatus*, *An. pallidus* and *An. tessellatus* mosquitoes in the study area. The reason behind the peculiar restricted pattern of biting rhythm with different mid-point peak exhibited by these mosquitoes *was* speculated by the co-existence and sharing the available hosts in the rural area for survival.

The variation in the mid-point values clearly indicated the adaptive feature of the mosquitoes, i.e. avoiding of competition among themselves by sharing the available vertebrate hosts for blood meal at the different periods in the diel cycle. Change in the landing and biting periodicity of *Ae. aegypti* [6] indicate the adaptation of parasite/pathogen as per the biting behavior of vector mosquitoes. Understanding the biting periodicity of mosquitoes in the diel cycle would helps in documenting the possible shift in the feeding behavior of mosquitoes due to global warming [13] and also to implement appropriate prevention and vector control strategies by reducing the man-vector contact adapting personal protection measures.

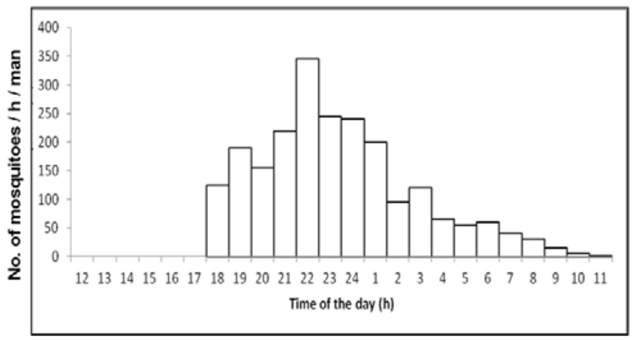

Fig 4. Number of *Culex quinquefasciatus* caught per man hour

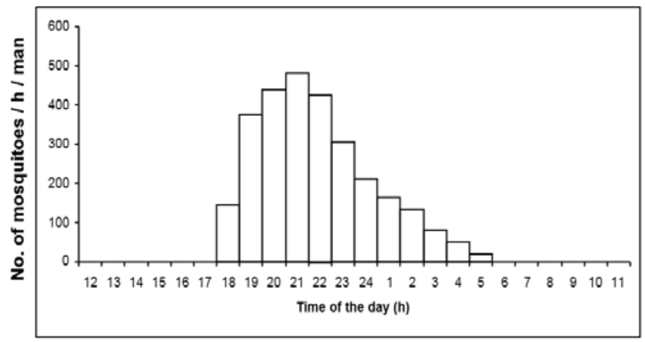

Fig 5. Number *Culex tritaeniorhynchus* caught per man hour

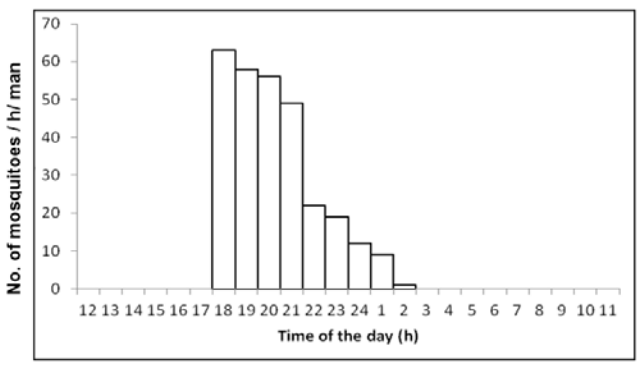

Fig 6. Number of *Culex gelidus* caught per man hour

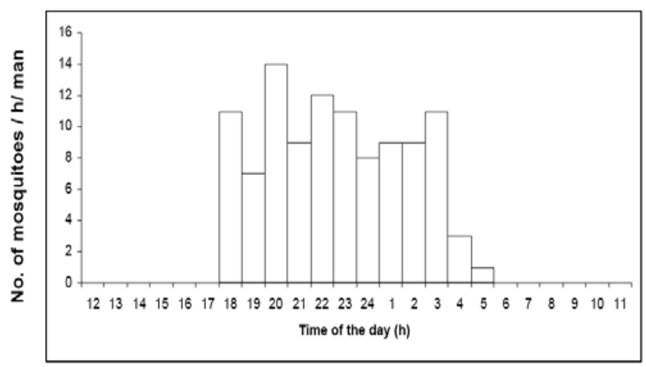

Fig 7. Number of *Culex infula* caught per man hour

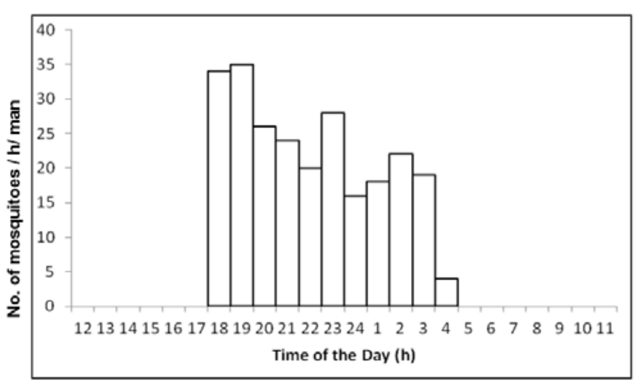

Fig 8. Number of *Culex vishnui* caught per man hour

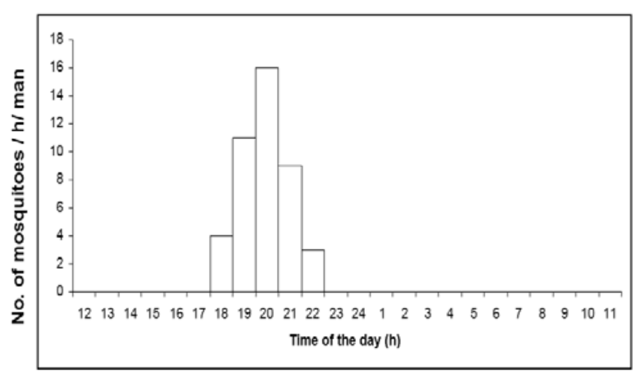

Fig 9. Number of *Culex pseudovishnui* caught per man hour

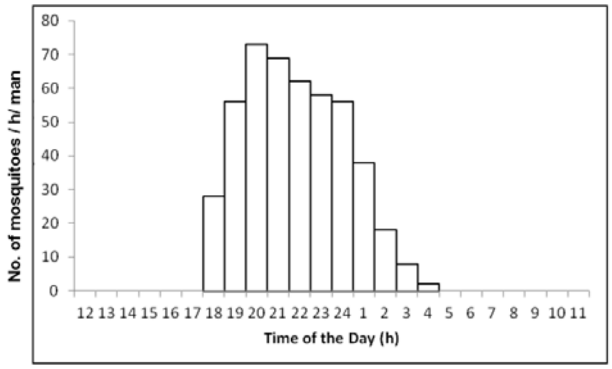

Fig 10. Number of *Anopheles hyrcanus group* caught per man hour

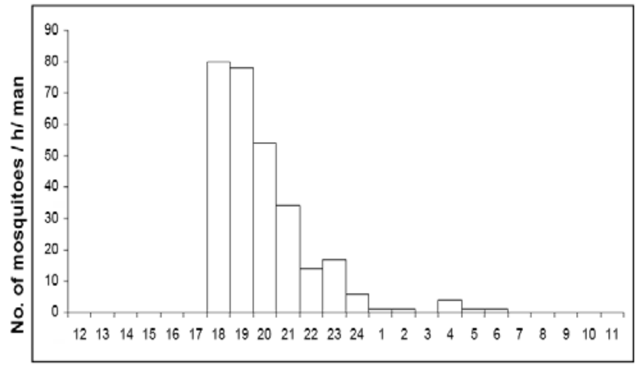

Fig 11. Number of *Anopheles subpictus* caught per man hour

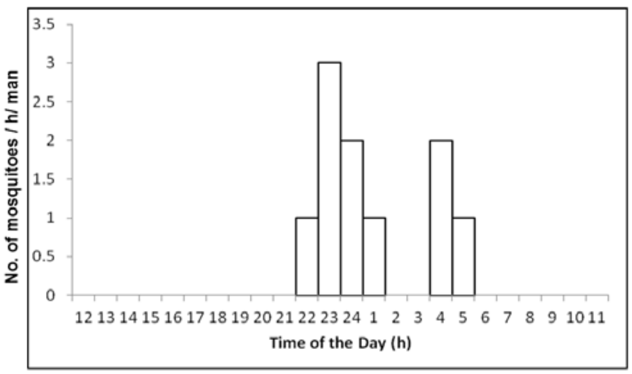

Fig 12. Number of *Anopheles barbirostris* caught per man hour

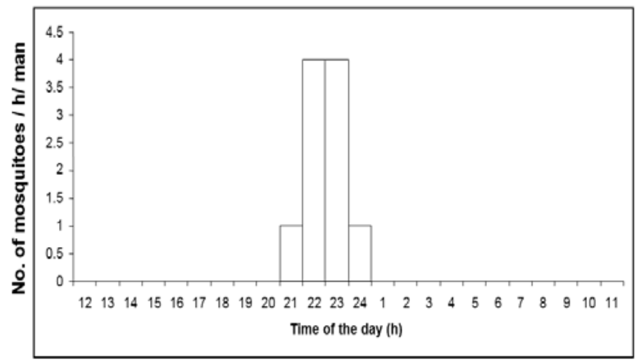

Fig 13. Number of *Anopheles vagus* caught per man hour

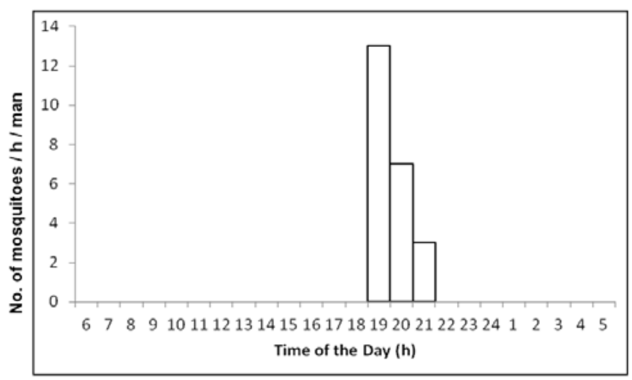

Fig 14. Number of *Aedes vexans* caught per man hour

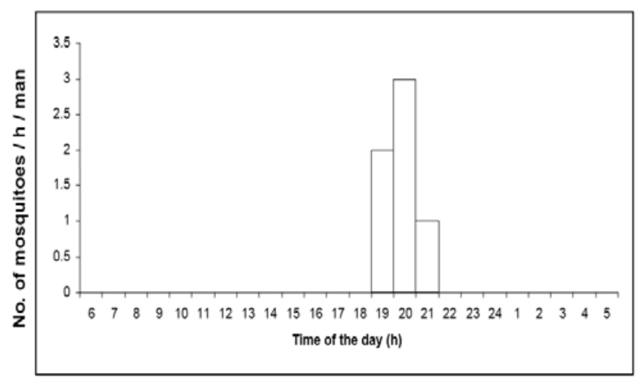

Fig 15. Number of *Aedes vittatus* caught per man hour

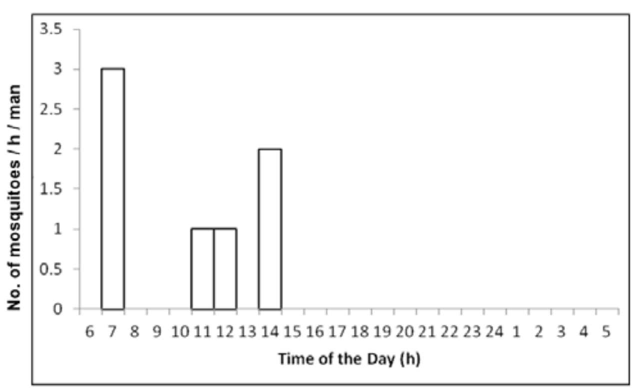

Fig 16. Number of *Aedes albopictus* caught per man hour

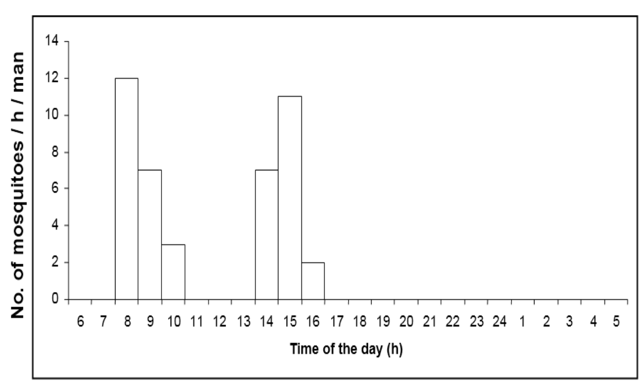

Fig 17. Number of *Aedes aegypti* caught per man hour

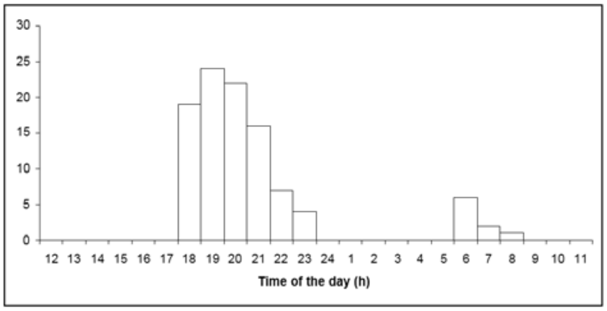

Fig 18. Number of *Armigeres subalbatus* caught per man hour

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