Pattern of Human-biting Activity of *Aedes aegypti* L. and *Aedes albopictus* Skuse in a Garden Locale from City of Kolkata, India

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Abstract

In a yearlong study, centering a garden in Kolkata possible competitive displacement of populations of *Ae. aegypti* and *Ae. albopictus* was suggested (Gilotra et al., 1967). After about 20 years, a comparative 24 h man-biting activity of *Ae. aegypti* and *Ae. albopictus* mosquitoes was investigated in the same garden from September 1986 to August 1987. During day light hours, altogether 248 *Ae. aegypti* mosquitoes were collected off human baits, of which 77 (31.04%) and 171 (68.95%) off indoor and outdoor baits respectively. The corresponding figures for *Ae. albopictus* were 867 [183 (21.10%) at indoors and 684 (78.89%) at outdoors]. Both species of mosquitoes were found to be attracted to human baits both at indoor and outdoor, throughout the day, with the peak hour of biting activity of *Ae. aegypti* between 8 and 9 a.m. [60 (24.19%)] followed by another peak during 5-6 p.m. [40 (16.13%)]. Peak activity of *Ae. albopictus* was observed between 5 and 6 p.m. (135 i.e. 15.5%). For both the species the peak biting activity was found in the month of July [Ae. aegypti, 52 (20.96%) and *Ae. albopictus*, 264 (30.4%)]. Altogether 36 and 13 *Ae. aegypti* were caught off man-baits at indoors and outdoors respectively beyond day light hours and the corresponding figures for *Ae. albopictus* were 56 and 34 respectively. This infers a possible competitive displacement of *Ae. aegypti* populations by the populations of *Ae. albopictus.*

Keywords: Man-landing activity; *Aedes aegypti*; *Aedes albopictus*; Retrospective study

1 Introduction

The genus *Aedes* is very large and comprises of more than one thousand species (Chandra, 2000). But, so far the medical importance is concerned, *Aedes aegypti* L. is the most important species being the vector of several deadly arboviruses like dengue, DHF, yellow fever, chikungunya, West Nile etc. (Duane, 2011). Another species i.e. *Ae. albopictus* Skuse has also been recognized important as vector of the viruses like dengue and chikungunya (Hochedez et al., 2006), West Nile, yellow fever, St Louis encephalitis (Randolf and Hardy, 1998) etc. There are evidences of interspecific competition between these two species. *Ae. albopictus* displaced *Ae. aegypti* in some places like areas of Calcutta (Brunette, 1907) and Hawaii (Usinger, 1944). On the other hand *Ae. aegypti* displaced *Ae. albopictus* in some places like Kuala Lampur (Stanton, 1920) and urban Bangkok (Rudnick, 1965). Senior White (White, 1934) first reported the changes in the relative proportions of these two mosquito species in Calcutta, India. Wattal (Wattal, 1964) found higher number of *Ae. aegypti* in Calcutta but higher number of *Ae. albopictus* in its outskirts. Chandra (1994) reported that in a two year long study in the urban Calcutta, out of 13,956 indoor-resting mosquitoes of different species collected, 137 (1.0%) was *Ae. aegypti* but no *Ae. albopictus* was found. According to Gilotra et al. (1967), when he took a comparative account between *Ae. aegypti* and *Ae. albopictus*, 98.8% of the larval specimens collected from urban premises of Calcutta and reared to adults were *Ae. aegypti*, whereas in an urban garden (The Marble Palace, situated in Central Calcutta) densities of *Ae. aegypti* were only 37.3%, indicating that in certain situations *Ae. albopictus* could spread its population taking environmental advantages.

After about 2 decades of the previous observation made on larval surveillance from all possible breeding places and by placing ovitraps (Gilotra et al., 1967), we conducted a yearlong man-biting study during 1986-87 in the same city garden. The present communication is a retrospective yearlong longitudinal
study to evaluate the degree of comparative man-biting activities of Ae. aegypti and Ae. albopictus both at indoors and outdoors in different months through the seasons and determine the intensity of man/vector contact of the two species.

3 Results
Altogether 248 Ae. aegypti mosquitoes were collected off human baits, of which 77 (31.04%) and 171 (65.95%) were off indoor and outdoor baits respectively. Though Ae. aegypti mosquitoes were found to be attracted to human baits throughout the day, the biting peak was noted during 8–9 a.m. (60 i.e. 24.2%) followed by another peak during 5–6 p.m. (40 i.e. 16.1%), both at indoor and outdoor locations (Table 1). In the first, second, third and fourth quadrant of the day, 98 (39.52%), 42 (16.93%), 28 (11.29%) and 80 (37.26%) Ae. aegypti mosquitoes were collected respectively. Peak biting activity of Ae. aegypti was found in the month of July [52 (20.96%)] followed by August [37 (14.91%)] (Table 2). In the winter (Nov – Feb), summer (Mar – June) and rainy seasons (Jul – Oct) 38 (15.3 %), 62 (25 %) and 148 (59.7%) Ae. aegypti mosquitoes were captured off human baits indicating that 60% of this species was collected off human baits in the rainy months.

Altogether 867 Ae. albopictus mosquitoes were captured off human baits, of which 183 (21.10%) and 684 (78.89%) were off indoor and outdoor baits respectively. Ae. albopictus mosquitoes were attracted to human baits throughout the day both at indoor and outdoor. The peak biting activity was observed during 5–6 p.m. [135 (15.57%)] followed by two other peaks during 4–5 p.m. [125 (14.41%)] and 3–4 p.m. [108 (12.45%)] (Table 1). In the first, second, third and fourth quadrant of the day 172 (19.89%), 146 (16.83%), 76 (20.29%) and 368 (42.44%) Ae. albopictus mosquitoes were collected.

About 52% [449 (51.78%)] of Ae. albopictus mosquitoes were caught off human baits, collectively from indoor and outdoor locations between 2 p.m. and 6 p.m. The peak biting activity was found in July [264 (30.4%)] followed by August [207 (23.8%)]. In this study no man landing activity of Ae. albopictus was observed in the months of January, February and April, both at indoor and outdoor. Only 19 (2.2%) man-landing Ae. albopictus mosquitoes were collected between December and April (Table 2). In the winter, summer and rainy months, 74 (8.5%), 85 (9.8%) and 708 (81.7%) Ae. albopictus mosquitoes were captured off human baits.

Both the species also landed on human baits beyond 6 a.m. to 6 p.m. both at indoors and outdoors (Table 3).

3.1 Season wise catches:
The number of man-landing Ae. aegypti in rainy season (148) was higher (p<0.05) than those of summer (62) and winter (38) [Z = 5.7966; Z = 7.910]. Number of this mosquito species landed in summer was also higher (p<0.05) than that of winter [Z=2.4].

The number of man-landing Ae. albopictus in rainy season (708) was higher (p<0.05) than those of

| Hour              | Indoor | Outdoor | Total | Indoor | Outdoor | Total |
|-------------------|--------|---------|-------|--------|---------|-------|
| 6 a.m – 7 a.m.    | 4 (5.19) | 9 (5.26) | 13 (5.24) | 4 (2.18) | 23 (3.36) | 27 (3.11) |
| 7 a.m – 8 a.m.    | 10 (11.99) | 15 (8.77) | 25 (10.08) | 17 (9.28) | 56 (8.18) | 73 (8.41) |
| 8 a.m – 9 a.m.    | 22 (28.52) | 38 (22.22) | 60 (24.19) | 17 (9.28) | 60 (8.77) | 77 (8.88) |
| 9 a.m – 10 a.m.   | 5 (6.49) | 13 (7.60) | 18 (7.25) | 18 (9.83) | 36 (5.26) | 54 (6.22) |
| 10 a.m – 11 a.m.  | 2 (2.19) | 13 (7.60) | 15 (6.04) | 2 (1.09) | 42 (6.14) | 44 (5.07) |
| 11 a.m – 12 a.m.  | 2 (2.59) | 7 (4.09) | 9 (3.63) | 8 (4.27) | 40 (5.84) | 48 (5.53) |
| 12 a.m – 1 p.m.   | 1 (1.29) | 7 (4.09) | 8 (3.22) | 11 (6.01) | 45 (6.57) | 56 (6.45) |
| 1 p.m – 2 p.m.    | 3 (3.89) | 6 (3.51) | 9 (3.63) | 6 (3.27) | 33 (4.82) | 39 (4.49) |
| 2 p.m – 3 p.m.    | 3 (3.89) | 8 (4.68) | 11 (4.43) | 16 (8.74) | 65 (9.50) | 81 (9.34) |
| 3 p.m – 4 p.m.    | 4 (5.19) | 12 (7.01) | 16 (6.45) | 18 (9.83) | 90 (13.15) | 108 (12.45) |
| 4 p.m – 5 p.m.    | 7 (8.99) | 17 (9.94) | 24 (9.67) | 30 (16.39) | 95 (13.88) | 125 (14.41) |
| 5 p.m – 6 p.m.    | 14 (18.18) | 26 (15.20) | 40 (16.13) | 36 (19.67) | 99 (14.47) | 135 (15.57) |
| Total             | 77 (100%) | 171 (100%) | 248 (100%) | 183 (100%) | 684 (100%) | 867 (100%) |

Table 1 House wise man-landing collection of Aedes aegypti and Aedes albopictus in a garden in Kolkata from 6 a.m. to 6 p.m.
summer (85) and winter (74) \([Z = 22.122; Z = 22.651]\) but the number of this mosquito species landed in summer was not higher (\(p>0.05\)) than that of winter \([Z= 0.7565]\).

### 3.2 Indoor and Outdoor Landing

At the day time, the man-landing propensity of \(Ae. aegypti\) and \(Ae. albopictus\) was noted to be significantly higher at outdoor than that at indoor ( \(Z = 5.9842; Z= 17.08\)).

### 3.3 Quadrant

The number of \(Ae. aegypti\) collected off man-baits in the first quadrant (98) was higher (\(p<0.05\)) than those of second (42) \((Z = 4.7329)\) and third quadrants (28) \((Z = 6.266)\) of the day. But the difference between the number of \(Ae. aegypti\) in the first quadrant and that in the fourth quadrant (80) was not (\(p>0.05\)) significant (\(Z =1.3842\)).

The number of \(Ae. albopictus\) collected off man-baits in the fourth quadrant (368) was higher (\(p<0.05\)) than those of first (172) \((Z = 8.412)\), second (146) \((Z = 9.789)\) and third quadrants (76) \((Z = 13.485)\) of the day.

### 4 Discussion

This man-landing study revealed certain interesting features. Both \(Ae. aegypti\) and \(Ae. albopictus\) mosquitoes were attracted to indoor and outdoor human baits indiscriminately throughout the day. Man-landing outdoor activity was greater than that of indoor activity in both the species (177 Vs 77 in \(Ae. aegypti\) and 684 vs. 183 in \(Ae. Albopictus\)). But a greater percentage of \(Ae. aegypti\) mosquitoes (31.05% i.e. 77 out of 248) were attracted to the indoor human baits than that of \(Ae. Albopictus\) (21.11% i.e. 183 out of 867), indicating that indoor activity of \(Ae. aegypti\) was more prominent than that of \(Ae. Albopictus\). Though both the species of mosquitoes were found to be attracted to human baits throughout the day, there were distinct pick activity hours, which for \(Ae. aegypti\) were from 8 a.m. – 9 a.m. i.e. in the first quadrant of the day and for \(Ae. Albopictus\) from 5 p.m. – 6 p.m. i.e. in the fourth or last quadrant of the day. In both the species the landing propensity increased in the monsoon months, with the peak in July. Significantly greater number of \(Ae. Albopictus\) mosquitoes than that of \(Ae. aegypti\) mosquitoes were attracted to human baits both at indoor and outdoor locations, showing that \(Ae. Albopictus\) mosquitoes

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**Table 2** Month wise man-landing collection of \(Ae. aegypti\) and \(Ae. albopictus\) in a garden in Kolkata during September 1986 to August 1987

| Month              | \(Ae. aegypti\) | \(Ae. albopictus\) |
|--------------------|-----------------|-------------------|
|                    | Indoor          | Outdoor           | Total | Indoor | Outdoor | Total |
| September 1986     | 10 (12.96)      | 22 (12.86)        | 32 (12.90) | 24 (13.11) | 51 (3.87) | 75 (8.65) |
| October            | 9 (11.68)       | 18 (10.52)        | 27 (10.88) | 22 (12.02) | 140 (21.60) | 162 (18.68) |
| November           | 4 (5.19)        | 10 (5.85)         | 14 (5.64) | 16 (8.74) | 45 (6.94) | 61 (7.03) |
| December           | 3 (3.89)        | 7 (4.09)          | 10 (4.03) | 3 (1.63) | 10 (1.54) | 13 (1.49) |
| January 1987       | 1 (1.29)        | 5 (2.92)          | 6 (2.41)  | 0      | 0      | 0     |
| February           | 3 (3.84)        | 5 (2.92)          | 8 (3.22)  | 0      | 0      | 0     |
| March              | 4 (5.19)        | 7 (4.09)          | 11 (4.43) | 5 (2.73) | 1 (0.15) | 6 (0.69) |
| April              | 2 (2.59)        | 3 (5.62)          | 11 (4.43) | 0      | 0      | 0     |
| May                | 5 (6.49)        | 12 (7.01)         | 17 (6.85) | 2 (1.69) | 43 (6.63) | 45 (5.19) |
| June               | 7 (9.09)        | 16 (9.35)         | 23 (9.27) | 10 (5.46) | 24 (3.70) | 34 (3.92) |
| July               | 17 (22.07)      | 35 (20.46)        | 52 (20.96) | 45 (24.59) | 219 (33.79) | 264 (30.44) |
| August             | 12 (11.58)      | 25 (14.62)        | 37 (14.91) | 56 (30.60) | 151 (23.30) | 207 (23.87) |
| Total              | 77 (100%)       | 171 (100%)        | 248 (100%) | 183 (100%) | 684 (100%) | 867 (100%) |

**Table 3** \(Ae.\) mosquitoes landed on man-bait beyond 6 a.m. to 6 p.m. at indoor and outdoor

| Species          | 6-7  | 7-8  | 8-9  | 9-10 | 10-11 | 11-12 | 12-1 | 1-2  | 2-3  | 3-4  | 4-5  | 5-6  | Total |
|------------------|------|------|------|------|-------|-------|------|------|------|------|------|------|-------|
| \(Ae. aegypti\)   | 11 (4) | 5 (1) | 8    | 3    | 0     | 0     | 0    | 0    | 0    | 0    | 3    | 6    | 36 (13) |
| \(Ae. albopictus\)| 17 (10) | 9 (5) | 9    | 6    | 1     | 0     | 0    | 0    | 0    | 0    | 5 (3) | 9 (16) | 56 (34) |

Figure in the brackets indicate catches off outdoor baits.

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This document contains a detailed analysis of mosquito behavior, specifically focusing on the man-landing collection of two mosquito species, \(Ae. aegypti\) and \(Ae. albopictus\), in a garden in Kolkata over a period from September 1986 to August 1987. The data includes monthly landing counts, distinguishing between indoor and outdoor conditions. The study found that while the number of \(Ae. aegypti\) mosquitoes landed off outdoor baits was significantly higher than indoor baits during the summer months, the difference was not as pronounced in the winter months. However, the number of \(Ae. albopictus\) mosquitoes landed off outdoor baits was consistently higher than indoor baits throughout the observed period. The analysis also highlighted the influence of the day's quadrants on mosquito landing patterns, with differences noted in the first, second, and third quadrants compared to the fourth quadrant. The study further underscored the importance of timing and location in mosquito behavior, with notable differences observed between indoor and outdoor environments. The data suggests that\(Ae. albopictus\) mosquitoes are more attracted to outdoor baits during the day, whereas \(Ae. aegypti\) mosquitoes exhibit a more indiscriminate attraction to both indoor and outdoor baits throughout the day.
might also be a serious pest in certain situations. Simultaneous attacks by both the species of mosquitoes on the same bait both at indoor and outdoor locations were observed. The environment of the Marble palace was found to be more favourable for the population build up of *Ae. albopictus* than for *Ae. aegypti* during the present study. A comparison with the previous study conducted on larval population (Gilotra et al., 1967) in the same niche suggested a possible competitive displacement between populations of *Ae. aegypti* and *Ae. albopictus* and this displacement during the present piece of work was in favour of *Ae. albopictus* mosquitoes.

This garden, where *Ae. albopictus* activity had been continuing for a prolonged period, might act as an epicenter to spread its population in the city of Kolkata.

Further in depth study is required related to the population densities of *Ae. aegypti* and *Ae. albopictus* in the whole city of Kolkata as there are evidences of the spread of population of *Ae. albopictus* in Singapore Reunion Island, Japan etc. (Yoshikawa et al., 2004) for beautification of cities and also for uplift of environment, which are suitable for the breeding of *Ae. albopictus*.

2 Materials and Methods

The study period extended from September 1986 to August 1987 in the marble palace garden of central Calcutta. The study was permitted by the ethical committee, Calcutta School of Tropical Medicine. For man-landing captures of mosquitoes the method adopted by Hati and coworkers (Hati et al., 1981) was followed. Hati et al., (1981) conducted man-bait collections during night for 12 hours but during the present study collections were conducted throughout the day and night i.e. for 24 hours.

Description of the Study Area

The area of the garden was 40,000 m² situated in a thickly populated area in Central Kolkata, with various plants, shrubs, bushes, herbs, a two storied marble building, several brick-built houses, a mini zoo (having few deer, peacock, cranes, cuckoos, a variety of small birds, rabbits, tortoise and monkeys) a car garage containing a pile of old tyres, a cattle shed and a horse stable. The animals were provided with drinking water in large molluscan shells and earthen, aluminium and tin pots.

The collection of mosquitoes off human baits (volunteers) was performed twice in a month. The indoor bait was placed in a room (10m×5m×8m) of the garden with two windows and one door. In open air, about 10 m away from the indoor bait, outdoor captures were made off the out door bait. At both indoor and outdoor, one man in each case was lying on a wooden cot, 0.5m above the ground wearing only shorts to serve as baits. Such human baits of the same age group were kept for 24 hours (6 a.m. to 6 a.m. of the next day) both at indoor and outdoor. In winter months, when the upper and lower extremities and belly were exposed, the chest and waist were wrapped in blankets. During rain the outdoor bait was protected by plastic sheets 4 m×3 m placed 3 m above the bait supported by 4 bamboo poles. Mosquito collectors were fully dressed with full sleeve white aprons, white trousers and cotton made shoes. The head of each collector was also covered with a white cap. For each of indoor and outdoor bait three collectors were allotted. The man-landing mosquitoes were caught with the help of battery operated torches and test tubes from 6 a.m. to 6 a.m. of the next day. Two of the collectors collected mosquitoes from two sides of the human bait and the third man noted the time of collection and the body parts from which the mosquitoes were collected. Hour wise catches of man-landing mosquitoes were kept in test tubes, plugged with cotton separately and identified in the central laboratory. Volunteers and mosquito collectors were replaced as and when required from the reserve. Hour wise, quadrant wise (a 12 hour day light period was divided in 4 quadrants of 3 hours each) and month wise numbers of caught man-landing mosquitoes were noted.

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