ABSTRACT: The diel landing/biting periodicity of the Trinidad strain of *Aedes aegypti* (L.) was monitored using human-bait during January-August 1999. Hourly light intensities were measured both indoors and outdoors at both urban and rural sites. The periodicity of females was diurnal and nocturnal, with 90% arriving during daylight and twilight and 10% during the night. The pattern of landing was trimodal, with consistent peaks at 0700h, 1100h and 1700h. The diel periodicities at indoor and outdoor urban sites were virtually identical. In contrast, the periodicities in rural areas differed, with no nocturnal activities being recorded at indoor and outdoor sites. At both urban and rural sites, larger numbers of adults were collected outside than inside houses. A significant correlation between light intensities and mosquito landing patterns was observed. The implications of the changing landing patterns of *Ae. aegypti* within urban areas are discussed in light of the epidemiology and control of dengue fever in Trinidad. *Journal of Vector Ecology* 25(2): 158-163. 2000.

Keyword Index: *Aedes aegypti*, landing/biting cycle, dengue, light regimen, epidemiology and control.

INTRODUCTION

The recent emergence and re-emergence of dengue fever and its hemorrhagic manifestations within the Caribbean region can be attributed to numerous anthropological factors including demographic and societal changes (Monath 1994, Gubler and Kuno 1997), post World War II increases in air-and sea-transportation (Monath 1994, Gubler and Kuno 1997), failure of *Aedes aegypti* programs due to a lack of political will (Rosenbaum et al. 1995, Gubler and Kuno 1997). The dengue pandemic within the Caribbean region has been attributed to numerous biological factors including the development of insecticide resistance in the vector *Ae. aegypti* (Rawlins 1998, Vaughan et al. 1998), the longer feeding times required for dengue-infected mosquitoes (Platt et al. 1997), changes in physical size and geographical origin of mosquito strains that enhanced their vector potential (Sumanochitrapon et al. 1998), and the introduction of different dengue strains or serotypes within the Caribbean region (Rico-Hesse 1990, Gubler and Kuno 1997).

The dengue pandemic within the Caribbean region has been attributed to numerous biological factors including the development of insecticide resistance in the vector *Ae. aegypti* (Rawlins 1998, Vaughan et al. 1998), the longer feeding times required for dengue-infected mosquitoes (Platt et al. 1997), changes in physical size and geographical origin of mosquito strains that enhanced their vector potential (Sumanochitrapon et al. 1998), and the introduction of different dengue strains or serotypes within the Caribbean region (Rico-Hesse 1990, Gubler and Kuno 1997). Behavioral studies show varying patterns in biting times of *Ae. aegypti* according to locality and also to the form or subspecies studied (Lumsden 1957, McClelland 1959, 1960, Teesdale 1955, Boorman 1960, Atmiosoedjono et al. 1972, Trpis et al. 1973, Corbet and Smith 1974 and Chadee 1988). Most studies show a characteristic diurnal landing pattern in Africa (van Someran et al. 1958, McClelland 1960, Boorman 1960, Trpis et al. 1973) and within the Americas (Chadee 1988) but some night-time feeding of *Ae. aegypti* has been reported in captive and wild populations in Africa (Macfie 1915, Teesdale 1955, Lumsden 1957).

Corbet and Smith (1974) reported a trimodal periodicity of landing of *Ae. aegypti* in Tanzania with peaks at 0600-0700h, 0800-0900h and 1700-1800h. The diel periodicities at indoor and outdoor sites were virtually identical. In contrast, the periodicities in rural areas differed, with no nocturnal activities being recorded at indoor and outdoor sites. At both urban and rural sites, larger numbers of adults were collected outside than inside houses. A significant correlation between light intensities and mosquito landing patterns was observed. The implications of the changing landing patterns of *Ae. aegypti* within urban areas are discussed in light of the epidemiology and control of dengue fever in Trinidad.
was conducted using human-bait collections, to re-examine the landing periodicity of Ae. aegypti females at urban and rural sites in Trinidad.

MATERIALS AND METHODS

This study was conducted during January-August 1999 at Woodbrook (10° 41'N; 61° 33'W), representing an urban site of approximately 200ha, 5000 people and 1000 houses, within the suburban area of the capital city of Port of Spain, and Tableland (10° 17'N; 61° 17'W) representing a rural community of approximately 100 ha, 2000 people and 500 houses, 31km east of San Fernando, the industrial capital of Trinidad.

Human bait captures were conducted according to the procedures outlined by Haddow (1954). Collections were made one day each week between 0400 and 2400 hours in two houses, with one man sitting on the porch (outside) and another sitting in the living room. Mosquito collectors worked a 10 h shift in the morning and afternoon. Mosquitoes were caught with hand nets or aspirators from the catcher’s lower legs and ankles and transferred into moistened plaster of Paris lined jars. After each hour, a new collection jar was used. The jars containing mosquitoes were labeled giving location, time of collecting, date and name of collector. These jars were then stored on ice and subsequently transported to the Insect Vector Control Division laboratory, St. Joseph, Trinidad where they were identified.

While mosquitoes were being collected, light intensities were simultaneously measured each hour at both indoor and outdoor sites and at both urban and rural locations using a standard Weston Master II photographic light meter (Model 753) facing directly upwards (incident light) and directly downwards (reflected light) at the center of the collection room. The mean reading was then calculated and recorded in foot candles.

RESULTS

A total of 1239 Ae. aegypti females was collected at the two sites, with 49.1% (278 indoors and 330 outdoors) in the urban area and 50.9 % (279 indoors and 352 outdoors) in the rural area (Table 1). Figure 1 shows the trimodal patterns of landing of the domestic strain of Ae. aegypti mosquitoes at indoor and outdoor sites in both urban Port of Spain and rural Tableland, Trinidad.

Within the urban area, the diel landing periodicity of Ae. aegypti was predominantly diurnal (90%) but with a small nocturnal component (10%). In contrast, in the rural area the landing periodicity was predominantly diurnal with no significant nocturnal activity (Figure 1). Females were collected during every daylight hour. In both the urban and rural areas the overall pattern was trimodal and similar with distinct peaks 1 hour after sunrise, 1 hour before noon and 1 hour before sunset.

Light measurements at both indoor and outdoor locations in Tableland and Woodbrook are shown in Figure 2. The light intensity measurements at both the urban and rural sites were similar during the periods 0500 to 1800 hours. However, from 1900 to 0100 hours, significantly (G=45.9 d.f. 12, P>0.01) lower intensities were measured at both indoor and outdoor

Table 1. Summary of collections of Aedes aegypti females landing on human bait at indoor and outdoor sites, in urban (Woodbrook) and rural (Tableland) Trinidad, West Indies (January-July, 1999).

<table>
<thead>
<tr>
<th>Sites</th>
<th>0500-0600</th>
<th>%</th>
<th>0600-1800</th>
<th>%</th>
<th>1800-1900</th>
<th>%</th>
<th>1900-0200</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>URBAN SITE</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Indoors</td>
<td>3</td>
<td>1.0</td>
<td>226</td>
<td>81.3</td>
<td>19</td>
<td>6.8</td>
<td>30</td>
<td>10.8</td>
</tr>
<tr>
<td>Outdoors</td>
<td>0</td>
<td>0.0</td>
<td>282</td>
<td>85.5</td>
<td>17</td>
<td>5.1</td>
<td>31</td>
<td>9.4</td>
</tr>
<tr>
<td>Sub-total</td>
<td>3</td>
<td>0.4</td>
<td>508</td>
<td>83.6</td>
<td>36</td>
<td>5.9</td>
<td>61</td>
<td>10.3</td>
</tr>
<tr>
<td><strong>RURAL SITE</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Indoors</td>
<td>0</td>
<td>0.0</td>
<td>273</td>
<td>98.0</td>
<td>6</td>
<td>2.0</td>
<td>0</td>
<td>0.0</td>
</tr>
<tr>
<td>Outdoors</td>
<td>0</td>
<td>0.0</td>
<td>352</td>
<td>100.</td>
<td>0</td>
<td>0.0</td>
<td>0</td>
<td>0.0</td>
</tr>
<tr>
<td>Sub-total</td>
<td>0</td>
<td>0.0</td>
<td>625</td>
<td>99.0</td>
<td>6</td>
<td>1.0</td>
<td>0</td>
<td>0.0</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>3</td>
<td>0.2</td>
<td>1133</td>
<td>91.4</td>
<td>42</td>
<td>3.4</td>
<td>61</td>
<td>5.0</td>
</tr>
</tbody>
</table>
Figure 1. Diel landing periodicity of *Aedes aegypti* at indoor (A) and outdoor (B) urban sites in Woodbrook and at indoor (C) and outdoor (D) rural sites in Tableland, Trinidad, West Indies. The number of females landing is expressed as percent.
Figure 2. Indoor (solid line) and Outdoor (dotted line) light intensity measurements (foot candles) at urban Woodbrook (A) and rural Tableland (B) sites in Trinidad, West Indies.

sites in the urban and rural areas (Figure 2).

DISCUSSION

The results of this study demonstrate that the diel landing periodicity of the Trinidad strain of *Ae. aegypti* is both diurnal and nocturnal (Figure 1). At both indoor and outdoor sites, the diel landing was tri-modal with peak landing occurring during the same three hours each day, with the peaks in the early morning and late afternoon being larger than that observed at mid-morning. Similar peaks in landing were observed at rural and urban indoor and outdoor sites in Trinidad (Fig.1).

These findings suggest that the trimodal patterns previously found by Atmosoedjono et al. (1972) in Indonesia and by Corbet and Smith (1974) in Tanzania were real and not due to sampling error, seasonal differences or geographical variations as suggested by those authors. However, in an earlier study using the same Trinidad strain of *Ae. aegypti*, Chadee (1988) observed a predominately diurnal landing pattern with only two peaks, one between 0600-0700 and the other at 1700-1800 hours. These results suggest that *Ae. aegypti* may have modified its landing activity at indoor and outdoor sites at both urban and rural areas.

Chadee (1988) reported a slightly extended landing period at indoor sites during 1800-2000 h but no landing adults were observed after 2000 h. It is noteworthy that Chadee and Corbet (1990) also found oviposition occurrences between 1800-2000 h and suggested it may have resulted from increased activity in homes and recommended that further studies were required. Here we provide additional data required to support that original inference and also to extend it. The collection of *Ae. aegypti* during nocturnal hours (1800-2400h) is new for the Trinidad strain but this feature is known to occur in Africa, where it is often confined to the 2 h following sunset (Macfie 1915, Teesdale 1955, Lumsden 1957, Van Someen et al. 1958; McClelland, 1959, 1960).

The “night-feeding” component observed at only the urban sites may have significant epidemiological consequences because it extends the period during which dengue transmission can occur. This extended window of opportunity for human-vector contact culminates at times of peak human activity as reported by Chadee (1988). That is, at late evening and at night when householders are usually casually dressed with more surface area of the human body exposed and accessible to landing *Ae. aegypti* mosquitoes. Therefore, the number of female *Ae. aegypti* per person (whether small or large in number) can increase transmission by multiple feeding (a feature well recognized by Macdonald 1956, Scott et al. 1993).
during these opportune periods of human presence and possible inactivity (e.g. watching television, computing or having dinner) and longer feeding hours. These factors may well explain the increase in the occurrence of clusters of dengue patients in the same household with similar dates of onset of illness (Morrison et al. 1998), the rapid and often explosive spread of dengue (Rodriguez-Figueroa et al. 1995) and the low prevalence of dengue in rural populations (Hayes et al. 1996).

In addition, the extension of the landing periodicity of Ae. aegypti during nocturnal hours may have occurred as an adaptation to light, that is, the effect of an increase in electrical lighting in and around houses may have had a similar effect to that observed among forest mosquitoes during moonlight. For example, Anopheles bellator Dyar and Knab shifted its peak landing periodicity from 1600-1800 to 1800-2000 hours during moonlight (Chadee 1992).

It is noteworthy that at both urban and rural sites most landing Ae. aegypti were collected when light intensities ranged from 15 to 25 foot candles and this suggests that internal and external lighting may influence the landing pattern of this vector species. Therefore, the increase in street lighting, use of dusk to dawn external security lighting and use of other internal light fittings in houses may have increased light intensities that mimic conditions similar to daylight/twilight within homes, thereby providing suitable conditions to extend the hours of landing activity by Ae. aegypti in urban environments. However, during the present study nocturnal activity was not observed in the rural area which was generally darker than the urban area, with minimal or no street lighting, only essential internal light fittings in houses and extensive shade and shadows cast by large trees (Figure 2). Consequently, due to the high intensity of light observed in some urban areas it is difficult to follow the strict definition of day and night due to the amount of artificial light measured during night-time. Mosquitoes found within cities and major townships in Trinidad and elsewhere may well modify or adapt their behavior to changing light regimens.

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