Host-feeding patterns of potential human disease vectors in the Paraíba Valley Region, State of São Paulo, Brazil

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ABSTRACT: Engorged females of Aedes albopictus, Ochlerotatus scapularis, Culex nigripalpus and Culex quinquefasciatus were collected by aspiration and sweep net during two years in Tremembé county, State of São Paulo, Brazil. Of the 1,092 specimens analyzed with the precipitin test, 87.6% reacted to one or more of the eight antisera tested. Of the four species for which the host determination was made, the reaction in 98.5% was to a single host. The application of the feeding index for four species of mosquitoes in Tremembé represented an attempt to measure and compare mosquito feeding patterns on these domestic hosts to evaluate the potential risk the region presents for the introduction and dissemination of arthropod-borne diseases. The results of the feeding index showed that Ae. albopictus commonly fed on humans and cattle; Oc. scapularis fed more upon cattle and dogs; Cx. nigripalpus fed on a wide range of hosts, and Cx. quinquefasciatus presented similar behavior but humans and dogs were the most common. The analysis of the feeding index agrees with the reported host feeding patterns of the four species investigated. Journal of Vector Ecology 28(1): 74-78. 2003.

Keyword Index: Mosquitoes, Culicidae, Aedes albopictus, Ochlerotatus scapularis, Culex nigripalpus, Culex quinquefasciatus, feeding pattern, serological methods, Tremembé.

INTRODUCTION

The southeastern region of Brazil was greatly affected by intense deforestation that resulted from urbanization and the development of agriculture and railways. The diversity of vertebrate and invertebrate fauna in many areas within this region, including the Paraíba Valley, has been impacted by these changes. Autochthonous populations of mosquitoes surviving this devastation did so by adapting to the modifications in their environment. As a result, new associations between mosquitoes and hosts can be expected, and the feeding patterns among mosquitoes, particularly host preferences, need to be investigated. The feeding behavior of these mosquitoes is relevant to an evaluation of the potential transmission of diseases by mosquito vectors within a given area. In this sense, it is expected that the reduction in wildlife will reinforce the associations between mosquitoes, humans and domestic animals.

In São Paulo State, little is known about the feeding habits of autochthonous mosquitoes. Forattini et al. (1988) described the feeding pattern of Ochlerotatus (Ochlerotatus) scapularis, distinguishing bovines as the hosts most sought after by this mosquito. There is no information available concerning the feeding habits of mosquitoes in the Paraíba Valley Region. A recent study produced a list of approximately eighty species of endemic mosquitoes that have survived decimation in this region (unpublished data). This study estimated the prevalence of Oc. scapularis, Culex (Culex) nigripalpus and Culex (Culex) quinquefasciatus over the remaining species. Aedes (Stegomyia) albopictus represented less than 5% of the total number of mosquitoes (10,751) identified in this study. This species, as well as Aedes (Stegomyia) aegypti are exotic populations that feed on humans in other regions.

From an epidemiological perspective, the five species mentioned above are all known to be involved in the transmission of arboviruses (Mitchell 1991, Savage et al. 1993, Mitchell and Forattini 1987), but no arbovirus transmission has yet been documented in the Paraíba Valley region. However, given the emergence or reemergence of these diseases (Gubler 1998), it is relevant to study the feeding pattern of these known vectors in order to establish a mosquito surveillance program for this region.

MATERIALS AND METHODS

Study site

For many decades the natural environment of the Paraíba Valley region was heavily modified by the emer-
gence and rapid dissemination of coffee plantations. At present, only 29% of the region is still covered by irregularly distributed secondary forest (Gomes et al. 1992). The municipality of Tremembé, located at 23º57’ S and 45º33’ W has an area of 174km² with 25,142 inhabitants. Approximately 80% of the territory is urbanized (Marques and Gomes 1997). Urban and peripheral sectors within the municipality were selected for this study.

Mosquito collections
During the 24-month study period, collections of mosquitoes were carried out indoors and outdoors. Each of the collections occurred monthly in these sectors, with each collection being considered an independent event. Mosquitoes were collected during the day, with most collections taking place in the morning. Diverse shelters were aspirated for fifteen minutes, generally in places within the shadows of large trees, within households, and near materials of domestic origin deposited immediately surrounding the household. Specimens were collected with hand-held power aspirators (Nasci 1981) and sweep nets (Forattini et al. 1987). The classification of the subgenus *Culex* that was used was based on Sirivanakarn (1976).

Animal census
A census of humans and domestic animals was carried out every month, concurrent with the mosquitoes catches. When counting humans, only those who had slept in the household the previous night were considered. Catches were replicated in each area and a monthly register of mosquitoes and domestic animals was obtained.

Serological methods
Engorged females collected in the field were placed in Ependorf tubes and held on ice. Tubes were later transferred to a freezer at –20°C. Females were ground within the tube with 0.5 ml of twice-distilled water. Blood meals were identified by precipitin tests (Boreham 1975), using a battery of antisera prepared against humans, dogs, cattle, horses, pigs, chicken, cats and rats (SIGMA Laboratory). The reaction was processed in a capillary tube containing the eluate of the female mosquito and the antiserum (Tempelis and Lofty 1963). The precipitin test had as a control mosquitoes that engorged on a known host.

Host-feeding pattern analysis
The feeding index (Kay et al. 1979b) was employed

<table>
<thead>
<tr>
<th>Species</th>
<th>% positive (N)</th>
<th>% negative (N)</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Ae. albopictus</em></td>
<td>75.3 (177)</td>
<td>24.7 (58)</td>
<td>235</td>
</tr>
<tr>
<td><em>Oc. scapularis</em></td>
<td>78.1 (211)</td>
<td>21.9 (59)</td>
<td>270</td>
</tr>
<tr>
<td><em>Cx. nigripalpus</em></td>
<td>99.4 (348)</td>
<td>0.6 (2)</td>
<td>350</td>
</tr>
<tr>
<td><em>Cx. quinquefasciatus</em></td>
<td>92.8 (220)</td>
<td>4.2 (17)</td>
<td>237</td>
</tr>
<tr>
<td>Total numbers</td>
<td>956</td>
<td>136</td>
<td>1,092</td>
</tr>
</tbody>
</table>

Table 2. Number of females and percentages of four species, and positive reactions for host source.

<table>
<thead>
<tr>
<th>Species</th>
<th>Aedes albopictus</th>
<th>Ochlerotatus scapularis</th>
<th>Culex nigripalpus</th>
<th>Culex quinquefasciatus</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sources</td>
<td>N  %</td>
<td>N  %</td>
<td>N  %</td>
<td>N  %</td>
</tr>
<tr>
<td>Human</td>
<td>118  50.2</td>
<td>53  19.6</td>
<td>65  18.5</td>
<td>122  51.5</td>
</tr>
<tr>
<td>Chicken</td>
<td>4   1.7</td>
<td>7   2.6</td>
<td>159  45.3</td>
<td>52   21.9</td>
</tr>
<tr>
<td>Cattle</td>
<td>15  6.4</td>
<td>98  36.3</td>
<td>77  21.9</td>
<td>10   4.2</td>
</tr>
<tr>
<td>Dog</td>
<td>6   2.5</td>
<td>28  10.4</td>
<td>38  10.8</td>
<td>22   9.2</td>
</tr>
<tr>
<td>Horse</td>
<td>4   1.7</td>
<td>5   1.8</td>
<td>6    1.7</td>
<td>3    1.2</td>
</tr>
<tr>
<td>Cat</td>
<td>1   0.4</td>
<td>2   0.7</td>
<td>1    0.2</td>
<td>8    3.4</td>
</tr>
<tr>
<td>Pig</td>
<td>4   1.7</td>
<td>3   1.1</td>
<td>1    0.3</td>
<td>0    0.0</td>
</tr>
<tr>
<td>Rat</td>
<td>25  10.6</td>
<td>15  5.5</td>
<td>1    1.7</td>
<td>3    1.2</td>
</tr>
<tr>
<td>Total</td>
<td>177 100.0</td>
<td>211 100.0</td>
<td>348 100.0</td>
<td>220 100.0</td>
</tr>
</tbody>
</table>
in our study of host-feeding patterns. Only humans, dogs, cattle, horses and chicken were included in this analysis. A quantitative analysis of blood meal results was undertaken to correlate feeding patterns with host availability. The feeding index was defined as the proportion of mosquitoes that fed on one host with respect to another host, divided by the expected comparative proportion of mosquitoes fed on two hosts, based on the factors that affect feeding. The study considered only the combination related to humans due to few mosquitoes engorging on several samples.

RESULTS

Species identifications
A total of 10,751 blood-fed female mosquitoes was captured. Of these, 1,437 were *Oc. scapularis*, 2,794 *Cx. nigripalpus*, 6,162 *Cx quinquefasciatus*, and 358 *Ae. albopictus*. Only 1,092 specimens were well engorged and tested by the precipitin method (Table 1). Census of 249 properties revealed that 649 people had resided in the households the previous night. The presence of 318 dogs, 85 horses, 120 cows, and 922 chicken was recorded.

Blood meal identifications
Host identity was successfully determined for 87.5% (956/1,092) of the engorged females; 98.5% of these (943/956) reacted only to one host. A total of 136 blood-meals did not react to any of the test antiserum (Table 1). Multiple reactions occurred in 14 cases; only two involved more than two hosts. Multiple reactions were identified in two *Ae. albopictus*, 10 *Oc. scapularis*, and two *Cx. nigripalpus*.

Overall, 73.6% (173/235) of *Ae. albopictus* fed on mammals, 1.7% on birds, and 58 specimens were non reactive (24.7%). Of the *Oc. scapularis*, 75.5% (204/270) had fed on mammals and 2.6% on birds. *Cx. nigripalpus* had fed on only mammals 54.0% (189/350) or mammals and birds (46.0%). *Cx. quinquefasciatus* fed on mammals (78.0%, 185/237) and birds (21.9%).

In general, reactions to precipitin reagents were more frequent with blood from humans (32.7%), chickens (20.3%), cattle (18.3%) and dogs (8.6%). *Ae. albopictus* and *Cx. quinquefasciatus* had the highest proportion of human blood meals and *Cx. nigripalpus* had the highest feeding rate on chickens. *Oc. scapularis* fed on cattle, and *Cx. quinquefasciatus* and *Cx. nigripalpus* fed more on fowl than the other species (Table 2). About 10% of the *Culex* and *Ochlerotatus* tested were positive for dog and 10% of *Ae. albopictus* had fed on rodents.

Feeding index analysis
Results of the feeding index analysis are presented in Table 3. Despite the presence of positive reactions for cats and pigs, the small numbers of reagents excluded them from analysis. Rats were excluded because it was impossible to determine their numbers.

The feeding index indicated a larger proportion of human blood meals among the *Ae. albopictus* when compared to chickens or dogs than would be expected. However, when comparing human and cattle blood meals, results indicate that this species fed on humans and cattle when both were equally available and abundant. Cattle and dog blood meals were predominant among *Oc. scapularis* when compared to chicken and horse blood meals. On the other hand, *Cx. nigripalpus* distinguished itself from other species due to the fact that its feeding pattern was not selective for human beings, revealing a tendency to feed on horse blood. The feeding pattern of *Cx. quinquefasciatus* indicated a higher proportion of feeds positive for human blood when compared to cattle, horses, and chickens. However, no particular preference could be detected when hosts were either humans or dogs.

<table>
<thead>
<tr>
<th>Species</th>
<th>Feeding Index</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>human/chicken</td>
<td>human/cattle</td>
<td>human/dog</td>
<td>human/horse</td>
</tr>
<tr>
<td><em>Aedes albopictus</em></td>
<td>41.90</td>
<td>1.45</td>
<td>9.64</td>
<td>3.86</td>
</tr>
<tr>
<td><em>Ochlerotatus scapularis</em></td>
<td>5.01</td>
<td>0.24</td>
<td>0.11</td>
<td>2.37</td>
</tr>
<tr>
<td><em>Culex nigripalpus</em></td>
<td>1.35</td>
<td>0.80</td>
<td>1.00</td>
<td>0.11</td>
</tr>
<tr>
<td><em>Culex quinquefasciatus</em></td>
<td>3.57</td>
<td>13.70</td>
<td>1.31</td>
<td>4.60</td>
</tr>
</tbody>
</table>
DISCUSSION

The application of the feeding index for four species of mosquitoes in Tremembé represented an attempt to measure mosquito feeding patterns for these domestic hosts to make it possible to evaluate the potential risk the region presents for the introduction and dissemination of arthropod-borne diseases. Seasons and places were taken into account for the mosquito catches and the results have been analyzed for their accuracy.

The results obtained in the Paraiba Valley Region demonstrate the predominant mammophily of three-quarters of the species that were tested. The absence of species with conspicuous ornithophily was a surprise, given the report that Cx nigripalpus has a preference for avian hosts (Edman and Taylor 1968).

The host-feeding patterns found in Tremembé demonstrate that human beings are an important host for Ae. albopictus. This species is known as an opportunistic blood-feeder (Savage et al. 1993), but in Tremembé county it fed on both cattle and humans equally. This result is interesting in as much as human beings were well-distributed among all the sectors, whereas cattle were confined to only a few of them. It is possible that the host-feeding patterns detected in this study may have been influenced by a predominant habit, identified among mosquitoes in the region, of feeding outside the households (Marques and Gomes 1995). A similar behavior has been noted among hosts in other locations outside of Brazil (Sullivan et al. 1971, Niebliski et. al. 1994, Savage et al. 1993). Consequently, the ability of Ae. albopictus to establish a hierarchy within its host-feeding pattern would not exclude the opportunistic character of this species (Savage et al. 1993), while at the same time, this is in general agreement with published information (Franco-Estrada and Craig 1995).

Cx. quinquefasciatus feeds on a diverse range of hosts involving mammals and avians (Irby and Apperson 1988). A study carried out in São Paulo revealed a tendency for this species to feed on human and avian blood (Forrattini et al. 1989). However, in American cities, dogs have proven to be the primary hosts of this species (Niebliski et al. 1994). A similar result was observed for the female of this species in Kowanyama, Australia, (Kay et al. 1979b). In the Paraiba Valley, this species fed on various animals but the feeding index showed that dogs were a source of food for Cx. quinquefasciatus. However, when both humans and dogs were available, it did not manifest selective behavior for either of these hosts. Forrattini et al. (1989) observed that species in the Valley of Ribeireiro region tended to feed more on humans and birds, but in the state of Rio de Janeiro it showed a great preference for dog (Labartht et al. 1998).

Oc. scapularis was distributed throughout the forest and the domestic environments, revealing interactions with mammals and birds (Forrattini et al. 1995). In the southern region of São Paulo State, it has been shown that large animals such as horses and cattle were sources of blood meals for this mosquito when analyses of the frequency of positive results for precipitin tests were carried out (Forrattini et al. 1989). However, our study confirmed its tendency towards mammophily and demonstrated a predominance of cattle and dog blood feeds when compared to human and bird blood feeds within this species’ host-feeding pattern. Oliveira-Hyeden (1985) considered Oc. scapularis as a species with a wide host range. In Argentina, its behavior is similar (Mitchell et al. 1985).

Cu. nigripalpus is frequently cited as an ornithophilic species (Edman and Webber 1975, Gabaldon et al. 1977), but in our study it demonstrated a non-selective feeding pattern although there was a discrete tendency to feed on horses in Tremembé county. In Florida, this mosquito manifested alternative feeding patterns on mammalian or bird hosts, according to the seasons of the year (Edman and Taylor, 1968). In the State of Rio de Janeiro, Guimarães et al. (1987) observed ornithophily in this species. The application of the feeding index corresponds to the description of this habit in Tremembé, besides indicating the opportunistic behavior of Cx. nigripalpus.

Acknowledgments

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REFERENCES CITED


Forrattini, O.P., A.C. Gomes, D. Natal, I. Kakitani, and


