AEDES AEGYPTI LARVAL HABITATS IN SURINAM

Milton E. Tinker, Ph. D.

Roof gutters can provide a good refuge for Aedes aegypti larvae. This article indicates that such gutters are the dominant A. aegypti habitat in Paramaribo, Surinam, where active eradication efforts have been carried out. In Albina, a town where these efforts had been discontinued, relatively larger numbers of ground-level infestations have been found.

Introduction

Aedes aegypti is one of the most widespread mosquito species on earth. Being present or having been present in all tropical and subtropical countries, it has developed diverse habitats in different parts of its range. In Africa, where it probably originated, the larvae commonly inhabit tree holes in swampy areas (Surtees, 1960); but in most of the world they are found primarily in man-made containers and only secondarily in natural containers. The containers most frequently used vary from place to place, depending on the types available. Major categories of artificial containers used by A. aegypti have ranged from tires and metal containers in Tanzania (Rao, et al., 1969) to ant traps and large earthenware jars in Malaya (MacDonald, 1965) to old tires in the United States (Tinker, 1964). Because of this adaptability, the mosquito’s habitat must be studied in the particular areas where it is to be controlled or eradicated in order to determine what containers play an important role in its propagation.

Surinam, where large numbers of A. aegypti larvae have been reported in roof gutters and catch basins, provides a case in point. These habitats have not been encountered often in other countries, and they have therefore been called “atypical” sites. However, they are more properly termed uncommon, rather than atypical, because they do possess the “typical” features required by A. aegypti. Thus extensive roof gutter infestations have also been found in other countries, such as Guyana, where large numbers of roof gutters exist (DeCaires, 1947).

The present study investigates the pattern of distribution of A. aegypti larvae in a number of typical areas of Surinam. The data presented here will show the importance of the various types of habitats involved.

Surinam has an active A. aegypti eradication campaign which employs the standard perifocal technique (PAHO, 1957). Every possible larval habitat on all premises is treated with fenthion and Abate on a two-month treatment cycle. In addition, due to heavy infestations special crews inspect and treat roof gutters. Because this latter work is time-consuming it involves a treatment cycle of about a year.

Because of the heavy infestations of A. aegypti in roof gutters after applications of insecticide, it has often been felt that the treatment of ground-level habitats was forcing A. aegypti into the roof gutters. An alternate hypothesis is that large numbers of A. aegypti have survived the applications because the gutters are very difficult to treat. These hypotheses can be tested by comparing mosquito habitats in treated and untreated areas—to determine whether the species prefers the roof gutter habitat or whether it is being driven there.

Procedures

The work reported here was based on a comprehensive survey made in February 1972.
of all possible larval habitats in five areas of Surinam.

**Selection Criteria**

In choosing these five areas, the following factors were considered: (1) climate, (2) size of the human community, (3) socioeconomic conditions, (4) past treatment history, and (5) past A. aegypti infestation record.

**Climate.** There is little climatic variation in Surinam. Because of this, climate was not used as a criterion in choosing survey areas. It should be noted, however, that the two localities surveyed had similar rainfall patterns (89.4 inches per year in Paramaribo and 97.5 inches in Albina) and that the surveys were done during the rainy season. During the 18 days of the investigation it rained some on all but three days.

**Community size.** A. aegypti infestations are generally larger and more complex in larger human communities. Thus a study that aspires to be complete should survey several communities of different size. Our particular investigation used the following size categories in selecting the communities to be surveyed:

1) Rural communities—no organized settlement;
2) Villages—less than 2,000 people, less than 500 houses;
3) Towns—2,000-10,000 people, 500-2,500 houses;
4) Cities—over 10,000 people, over 2,500 houses.

For lack of time and because lower infestation rates have generally been found in rural areas and villages of Surinam, it was decided that the survey would cover four areas in the city of Paramaribo and one in the town of Albina.

**Socioeconomic conditions.** Infestations of A. aegypti usually correlate strongly with socioeconomic conditions (Tinker, 1964). The highest infestations are generally found at the lower socioeconomic levels and the lowest infestations at the upper socioeconomic levels. The five socioeconomic land-use categories listed below were considered in choosing the areas to be surveyed:

1) Lower-level residential: Small homes, often crowded and in poor condition, whose residents are usually members of the laboring class.
2) Middle-level residential: Medium-sized homes, generally in good condition, whose residents are usually members of the middle class.
3) Upper-level residential: Large homes, all in good condition.
4) Business areas: Shops and light industry.
5) Industrial areas: Large factories and warehouses, often with sizeable lots used for storage.

While one of these categories usually predominates, there are often mixtures, especially in the lower residential and business areas. In towns and villages no one category is large enough to be sampled separately except for the lower residential area.

**Treatment history.** Treatment would logically be expected to change the pattern of infestation. Such change depends on the amount and type of treatment. Therefore, the following patterns of past treatment were considered in choosing the areas to be studied: (1) No treatment; (2) Recent treatment (for less than a year); (3) Lapsed treatment (for more than one treatment cycle); and (4) Long-term treatment (for more than a year). The pattern of infestation in categories (1) and (3) should be similar, especially after a long lapse. In Surinam all towns have been treated for more than a year, but the treatment in some places has lapsed. Albina was picked as an example of the latter to provide a basis for comparison with Paramaribo, which has received long-term treatment.

**Record of Infestation.** The pattern of infestation can be expected to vary with the infestation rate. At the higher rates all possible habitats will be occupied, while at lower rates infestations will be found only in the most favorable habitats or in those where treatment
has been relatively unsuccessful. The four categories of infestation used in choosing study areas were adopted from the Manual of Operations for an Aedes aegypti Eradication Service (PAHO, 1957). These are: (1) high (over 15 per cent of the houses infested); (2) moderate (2-15 per cent of the houses infested); (3) slight (infestation, but less than 2 per cent of the houses infested); (4) uninfested.

Because of the short time available, it was felt that study areas should be picked where recent surveys had shown moderate or high levels of infestation, so that a statistically significant number of infestations would be found. This eliminated most towns and upper-level residential areas, because they were either uninfested or had only slight infestations.

Based on these considerations, four areas were picked in Paramaribo and one in Albina. Those in Paramaribo are areas where persistent infestations have been undergoing long-term treatment. They can be categorized as follows:

Area 1—Lower-level residential, near city center;
Area 2—Lower-level residential, at edge of city;
Area 3—Middle-level residential;
Area 4—Old lower-level residential area bordering business districts.

Portions of areas 2 and 4 contain middle-class residences. The Albina area, where treatment had lapsed, was typical of town areas in that it contained a mixture of businesses, lower-class residences, and middle-class residences.

**Sampling Technique**

All premises were thoroughly inspected both inside and out. A census was made of all potential A. aegypti habitats, including roof gutters: all were classified, counted, examined, and all infestations were noted. A sample of larvae was collected from each infestation site and identified microscopically. In all cases the preliminary identification of larvae as A. aegypti was confirmed.

A standard list was used to classify potential habitats. This list included the following entries: cisterns or tanks, drums and barrels, clay containers, water plants, small containers, roof gutters, tires, other containers, street catch basins, and tree holes.

**Results and Discussion**

**Infestation Levels**

In each area the level of infestation was determined (see Table 1). In Paramaribo, area 1 had a moderate level of infestation while areas 2, 3, and 4 had high levels. The Albina area was very heavily infested.

**Containers**

A particular type of container can play an

<table>
<thead>
<tr>
<th>Survey area</th>
<th>Houses inspected</th>
<th>Houses infested with A. aegypti*</th>
<th>% infested houses with gutter vs. ground infestation sites*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total No.</td>
<td>%</td>
<td>In gutter No.</td>
</tr>
<tr>
<td>Area 1</td>
<td>95</td>
<td>8</td>
<td>84</td>
</tr>
<tr>
<td>Area 2</td>
<td>104</td>
<td>21</td>
<td>20.2</td>
</tr>
<tr>
<td>Area 3</td>
<td>118</td>
<td>20</td>
<td>17.0</td>
</tr>
<tr>
<td>Area 4</td>
<td>84</td>
<td>22</td>
<td>26.2</td>
</tr>
<tr>
<td>Paramaribo (subtotal)</td>
<td>401</td>
<td>71</td>
<td>17.7</td>
</tr>
<tr>
<td>Albina</td>
<td>114</td>
<td>45</td>
<td>39.5</td>
</tr>
<tr>
<td>Total</td>
<td>515</td>
<td>116</td>
<td>22.5</td>
</tr>
</tbody>
</table>

* Houses with both gutter and ground infestations are listed in all columns.
### TABLE 2—Numbers of containers found, listed by type.

<table>
<thead>
<tr>
<th>Survey area</th>
<th>Small containers</th>
<th>Miscellaneous containers</th>
<th>Roof gutters</th>
<th>Water plants</th>
<th>Barrels and drums</th>
<th>Tires</th>
<th>Catch basins</th>
<th>Clay containers</th>
<th>Cisterns or tanks</th>
<th>Tree holes</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No.</td>
<td>% of total</td>
<td>No.</td>
<td>% of total</td>
<td>No.</td>
<td>% of total</td>
<td>No. with</td>
<td>No. with</td>
<td>No. with</td>
<td>No. with</td>
<td>No.</td>
</tr>
<tr>
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<td>197</td>
<td>7.3</td>
<td>117</td>
<td>4.2</td>
<td>26</td>
<td>13</td>
<td>37</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>Area 2</td>
<td>2,147</td>
<td>81.4</td>
<td>169</td>
<td>6.4</td>
<td>171</td>
<td>6.5</td>
<td>38</td>
<td>41</td>
<td>52</td>
<td>9</td>
<td>6</td>
</tr>
<tr>
<td>Area 3</td>
<td>2,995</td>
<td>75.0</td>
<td>386</td>
<td>9.7</td>
<td>790</td>
<td>7.0</td>
<td>108</td>
<td>25</td>
<td>76</td>
<td>99</td>
<td>12</td>
</tr>
<tr>
<td>Area 4</td>
<td>1,838</td>
<td>77.7</td>
<td>164</td>
<td>6.9</td>
<td>247</td>
<td>10.4</td>
<td>46</td>
<td>10</td>
<td>30</td>
<td>20</td>
<td>10</td>
</tr>
<tr>
<td>Paramaribo (subtotal)</td>
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<td>78.4</td>
<td>916</td>
<td>7.8</td>
<td>110</td>
<td>6.9</td>
<td>210</td>
<td>89</td>
<td>195</td>
<td>134</td>
<td>34</td>
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<tr>
<td>Albina</td>
<td>2,621</td>
<td>80.1</td>
<td>126</td>
<td>3.8</td>
<td>201</td>
<td>6.1</td>
<td>52</td>
<td>164</td>
<td>50</td>
<td>2</td>
<td>16</td>
</tr>
<tr>
<td>Total</td>
<td>11,886</td>
<td>79.5</td>
<td>1,042</td>
<td>7.0</td>
<td>1,011</td>
<td>6.8</td>
<td>270</td>
<td>253</td>
<td>245</td>
<td>136</td>
<td>50</td>
</tr>
</tbody>
</table>

### TABLE 3—Numbers of containers found with water.

<table>
<thead>
<tr>
<th>Survey area</th>
<th>Small containers</th>
<th>Miscellaneous containers</th>
<th>Roof gutters</th>
<th>Water plants</th>
<th>Barrels and drums</th>
<th>Tires</th>
<th>Catch basins</th>
<th>Clay containers</th>
<th>Cisterns or tanks</th>
<th>Tree holes</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No. with water</td>
<td>% with water</td>
<td>No. with water</td>
<td>% with water</td>
<td>No. with water</td>
<td>% with water</td>
<td>No. with</td>
<td>No. with</td>
<td>No. with</td>
<td>No. with</td>
<td>No.</td>
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<tr>
<td>Area 1</td>
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<td>18.8</td>
<td>54</td>
<td>27.4</td>
<td>75</td>
<td>8.0</td>
<td>18</td>
<td>3</td>
<td>7</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>Area 2</td>
<td>431</td>
<td>16.8</td>
<td>63</td>
<td>37.3</td>
<td>152</td>
<td>54.3</td>
<td>87</td>
<td>4</td>
<td>16</td>
<td>90</td>
<td>7</td>
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<td>Area 3</td>
<td>430</td>
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<td>161</td>
<td>57.5</td>
<td>68</td>
<td>27.5</td>
<td>41</td>
<td>4</td>
<td>16</td>
<td>18</td>
<td>0</td>
</tr>
<tr>
<td>Area 4</td>
<td>227</td>
<td>12.9</td>
<td>89</td>
<td>84.3</td>
<td>89</td>
<td>43.9</td>
<td>27</td>
<td>21</td>
<td>14</td>
<td>8</td>
<td>2</td>
</tr>
<tr>
<td>Paramaribo (subtotal)</td>
<td>1,453</td>
<td>15.7</td>
<td>428</td>
<td>46.7</td>
<td>304</td>
<td>37.5</td>
<td>173</td>
<td>32</td>
<td>45</td>
<td>120</td>
<td>4</td>
</tr>
<tr>
<td>Albina</td>
<td>485</td>
<td>18.3</td>
<td>54</td>
<td>42.9</td>
<td>102</td>
<td>50.7</td>
<td>46</td>
<td>85</td>
<td>32</td>
<td>2</td>
<td>7</td>
</tr>
<tr>
<td>Total</td>
<td>1,943</td>
<td>16.3</td>
<td>482</td>
<td>46.3</td>
<td>406</td>
<td>40.2</td>
<td>219</td>
<td>117</td>
<td>77</td>
<td>122</td>
<td>11</td>
</tr>
</tbody>
</table>

### TABLE 4—Numbers of containers infested with *A. aegypti.*

<table>
<thead>
<tr>
<th>Survey area</th>
<th>Small containers</th>
<th>Roof gutters</th>
<th>Water plants</th>
<th>Miscellaneous containers</th>
<th>Barrels and drums</th>
<th>Tires</th>
<th>Catch basins</th>
<th>Clay containers</th>
<th>Cisterns or tanks</th>
<th>Tree holes</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No. of infested</td>
<td>of containers</td>
<td>No. of infested</td>
<td>of containers</td>
<td>No. of infested</td>
<td>of containers</td>
<td>No. of infested</td>
<td>of containers</td>
<td>No. of infested</td>
<td>of containers</td>
<td>No. of infested</td>
</tr>
<tr>
<td>Area 1</td>
<td>1</td>
<td>0.04</td>
<td>11.1</td>
<td>5</td>
<td>4.5</td>
<td>55.6</td>
<td>3</td>
<td>11.5</td>
<td>33.3</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Area 2</td>
<td>3</td>
<td>0.1</td>
<td>10.3</td>
<td>24</td>
<td>14.0</td>
<td>82.8</td>
<td>0</td>
<td>0.0</td>
<td>0.0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Area 3</td>
<td>12</td>
<td>0.4</td>
<td>40.0</td>
<td>13</td>
<td>4.6</td>
<td>43.3</td>
<td>1</td>
<td>5.9</td>
<td>3.3</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Area 4</td>
<td>6</td>
<td>0.3</td>
<td>18.8</td>
<td>18</td>
<td>7.3</td>
<td>56.2</td>
<td>5</td>
<td>10.9</td>
<td>15.6</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Paramaribo (subtotal)</td>
<td>22</td>
<td>0.2</td>
<td>22.0</td>
<td>60</td>
<td>7.4</td>
<td>60.0</td>
<td>9</td>
<td>4.1</td>
<td>9.0</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>Albina</td>
<td>30</td>
<td>1.1</td>
<td>34.9</td>
<td>22</td>
<td>10.9</td>
<td>25.6</td>
<td>14</td>
<td>26.9</td>
<td>16.3</td>
<td>2</td>
<td>13</td>
</tr>
<tr>
<td>Total</td>
<td>52</td>
<td>0.4</td>
<td>28.0</td>
<td>82</td>
<td>8.1</td>
<td>44.1</td>
<td>23</td>
<td>8.5</td>
<td>12.4</td>
<td>5</td>
<td>13</td>
</tr>
</tbody>
</table>
important role in *A. aegypti* propagation if a high percentage of the infested containers are of that type. This can come about if many containers are of the type in question, or if a large proportion of that particular type are infested. In our survey the first case was illustrated by small containers, the second by drums in Albina and by roof gutters in both Albina and Paramaribo.

The distribution of the different types of containers was typical (see Table 2). Most of the containers (79 per cent) were classified as small containers (these were mostly tin cans). Still, the number of such containers was not great when compared with other countries, the overall average per premises being 23 small containers. In Jamaica the average per premises is 120. While we found them to produce many infestations, they were not a good habitat. Only a small proportion (16.3 per cent) contained water (Table 3), and only 0.4 per cent were actually infested; but because there were so many they accounted for a significant proportion (28 per cent) of all infestations, as shown in Table 4.

**Water-plant containers and tires.** Fewer water-plant containers and tires were found than might have been expected, these types respectively accounting for only 1.8 and 1.6 per cent of all containers. On the other hand, both types provided good habitats and both harbored a significant proportion of the infestations. Overall, 8.5 per cent of the water plants were infested and these accounted for 17.4 per cent of the total number of infestations. The respective figures for tires were 2.0 and 2.7 per cent (see Table 4).

The water plants' role appears less important when it is considered that 12 of the 14 infested water plants in Albina were found on the premises of one house. Without these premises the water plants' share of the total infestation observed in Paramaribo and Albina would drop from 17.4 to 5.9 per cent. Though this is still an important figure, growing plants in water has not been as widespread in Surinam as in the islands of the Caribbean. For example, in untreated parts of Jamaica water plants have been found to account for 30 per cent of the infestations.

**Drums and Tanks.** Water stored in drums and tanks provided an important habitat in Albina but not in Paramaribo. This was true even though the proportion of Albina surveyed does have a piped water supply. In Paramaribo the number of drums was low, making up only 0.8 per cent of all the containers; in contrast, they were relatively common in Albina, where they represented 5.0 per cent.

The same observations were true of tanks. They made up 0.3 per cent of the containers in Paramaribo and 1.3 per cent in Albina, and this difference showed up even more sharply in the infestations found. Only one drum or tank infestation was observed in Paramaribo, this being in an ornamental tank. On the other hand, two infested tanks and 13 infested drums were found in Albina, these constituting 2.3 per cent and 15.1 per cent of the infestations there. The differences presumably stem from Paramaribo's ban on water storage and its active *A. aegypti* eradication campaign.

**Catch basins.** Also known locally as "rain gullies," these are considered an atypical habitat for *A. aegypti*, but they do meet the general requirements of a container with hard sides and a fluctuating water level.

A catch basin is the structure which receives rainwater from the street and passes it into the storm sewer. Within it is a small settling basin which contains water all the time, and which has the purpose of removing debris from the water so as to prevent the sewer from clogging up. This is an ideal habitat for *Culex fatigans* and occasionally *A. aegypti*.

In many U.S. cities catch basins are the main source of *Culex fatigans* and are treated regularly. Occasionally *A. aegypti* have also been found in them, particularly when the general level of *A. aegypti* infestation was high. This pattern appears to be the one prevailing in Surinam. Of the 136 catch basins inspected only one was found to be infested with *A.
A. aegypti. On the other hand, 26 of them (19 per cent) were infested with C. fatigans. In the two areas with a significant number of catch basins (areas 3 and 4) they were a C. fatigans habitat of considerable importance. The two areas had the largest numbers of C. fatigans infestations, and the catch basins alone accounted for 76.9 and 66.7 per cent of these (see Table 5).

Roof gutters. The results of our study show that roof gutters are the dominant habitat of A. aegypti in Surinam. In Paramaribo, this one category of container was responsible for 60.0 per cent of the infestations observed and for 66.2 per cent of the infested premises (see Tables 1 and 4). It was thus more important than all the other categories of containers combined.

This major role resulted partly from the large number of roof gutters in use and partly from the high proportion of gutters infested. They were the third most common type of containers, after small containers and other containers; and they had the highest infestation rate (7.4 per cent) of any category, the next highest categories being water plants (4.1 per cent) and tires (1.5 per cent).

The same was true in Albina, where roof gutters were the site of infestation on 33 per cent of the infested premises, were the second most common type of container (6.1 per cent of the total), and had the second highest rate of infestation (10.9 per cent). The Albina survey showed water-plant containers to have the highest rate of infestation (26.9 per cent), but this was due to the high rate at a single premises where 12 of 20 water plants were infested. In the rest of the 113 premises surveyed, only two of 32 (6.5 per cent) were infested. Other containers with high infestation rates in Albina were drums (7.9 per cent), tanks (4.8 per cent), and tires (4.0 per cent).

One of the most important factors behind this pattern was the high proportion of buildings with roof gutters in both Paramaribo and Albina (see Table 6). On the average 66.1 per cent of the buildings had them in Paramaribo and 62.3 per cent in Albina. Many of these gutters contained water (56.2 per cent in Paramaribo, 67.6 per cent in Albina), and nearly a third of those containing water were infested (31.5 per cent in Paramaribo and 31.3 per cent in Albina). In areas 1 and 2 the percentage of wet gutters infested was especially high (57.1 per cent in area 1 and 50.0 per cent in area 2).

Two sets of data indicate that roof gutter infestations are often the source of infestations in containers on the ground. These are (1) the distribution of infestations with pupae (pupal foci) and (2) the spatial relationship of gutter and ground infestations.

When infested water contains pupae, this is generally recognized as a sign that the focus of infestation is well established and is providing a source for infestation of surrounding areas. This is generally true, though in the case of containers with highly intermittent water it is possible for one brood to emerge before the eggs for the next brood are hatched. Thus some established sources of infestation will not contain pupae if they are inspected too soon after the eggs hatch.

**TABLE 5—Catch basins and Culex fatigans infestations.**

<table>
<thead>
<tr>
<th>Survey area</th>
<th>All containers</th>
<th>Catch basins</th>
<th>Percentage of C. fatigans infestations found in catch basins</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No. inspected</td>
<td>No. with A. aegypti</td>
<td>No. with C. fatigans</td>
</tr>
<tr>
<td>Area 1</td>
<td>2,658</td>
<td>9</td>
<td>2</td>
</tr>
<tr>
<td>Area 2</td>
<td>2,637</td>
<td>29</td>
<td>2</td>
</tr>
<tr>
<td>Area 3</td>
<td>3,991</td>
<td>30</td>
<td>26</td>
</tr>
<tr>
<td>Area 4</td>
<td>2,366</td>
<td>32</td>
<td>9</td>
</tr>
<tr>
<td>Paramaribo (subtotal)</td>
<td>11,682</td>
<td>100</td>
<td>39</td>
</tr>
<tr>
<td>Albina</td>
<td>3,274</td>
<td>86</td>
<td>6</td>
</tr>
<tr>
<td>Total</td>
<td>14,956</td>
<td>186</td>
<td>45</td>
</tr>
</tbody>
</table>
TABLE 6—A. aegypti roof gutter infestations.

<table>
<thead>
<tr>
<th>Survey area</th>
<th>Total No.</th>
<th>With roof gutters</th>
<th>No.</th>
<th>%</th>
<th>With water in gutters</th>
<th>No.</th>
<th>%</th>
<th>With A. aegypti-infested gutters</th>
<th>No.</th>
<th>%</th>
<th>% with water in A. aegypti gutters</th>
<th>% with A. aegypti infested gutters</th>
</tr>
</thead>
<tbody>
<tr>
<td>Area 1</td>
<td>100</td>
<td>104</td>
<td>63</td>
<td>60.6</td>
<td>36</td>
<td>34.6</td>
<td>18</td>
<td>17.3</td>
<td>18</td>
<td>17.3</td>
<td>9.5</td>
<td>57.1</td>
</tr>
<tr>
<td>Area 2</td>
<td>118</td>
<td>90</td>
<td>76.3</td>
<td>76.3</td>
<td>67</td>
<td>56.8</td>
<td>10</td>
<td>8.5</td>
<td>10</td>
<td>8.5</td>
<td>11.1</td>
<td>14.9</td>
</tr>
<tr>
<td>Area 3</td>
<td>84</td>
<td>70</td>
<td>83.3</td>
<td>83.3</td>
<td>39</td>
<td>46.4</td>
<td>15</td>
<td>17.9</td>
<td>15</td>
<td>17.9</td>
<td>21.7</td>
<td>38.5</td>
</tr>
<tr>
<td>Area 4</td>
<td>180</td>
<td>144</td>
<td>80</td>
<td>80.0</td>
<td>36</td>
<td>20.0</td>
<td>10</td>
<td>5.6</td>
<td>10</td>
<td>5.6</td>
<td>12.1</td>
<td>14.9</td>
</tr>
<tr>
<td>Paramaribo (subtotal)</td>
<td>400</td>
<td>265</td>
<td>66.1</td>
<td>66.1</td>
<td>149</td>
<td>37.2</td>
<td>47</td>
<td>11.7</td>
<td>47</td>
<td>11.7</td>
<td>17.7</td>
<td>31.5</td>
</tr>
<tr>
<td>Albina</td>
<td>250</td>
<td>201</td>
<td>80</td>
<td>80.0</td>
<td>149</td>
<td>59.1</td>
<td>40</td>
<td>15.6</td>
<td>40</td>
<td>15.6</td>
<td>23.1</td>
<td>44.4</td>
</tr>
</tbody>
</table>

In both Paramaribo and Albina, a higher proportion of the infestations with pupae were found in the gutters than on the ground (see Table 7). In Paramaribo 52.2 per cent of the gutter infestations were classed as pupal foci, as opposed to only 25.0 per cent of those on the ground; and in Albina, 72.7 per cent of the gutter infestations were pupal foci, while only 12.1 per cent of the ground infestations were of this type. Stated another way, 52.1 per cent of the premises with roof gutter infestations in Paramaribo had pupal foci, but this was true of only 30 per cent of those with ground infestations. Likewise, in Albina pupal foci were found on 60.0 per cent of the premises with roof gutter infestations but on only 15.6 per cent of those with infestations at ground level. These findings indicate that roof gutters are a frequent source of further infestation in both Paramaribo and Albina.

To further examine the relation between ground and gutter infestations, all locations were marked on a map and were classified in terms of their proximity to each other (see Table 8). Most of these classifications were confirmed in the field. Based on these data, each house surveyed was placed in one of the following categories:

1) With independent gutter infestation;
2) With independent ground infestation;
3) With one or more gutter infestations located less than 50 m from a ground infestation;
4) With one or more ground infestations located less than 50 m from a gutter infestation;
5) With both gutter and ground infestations.

In Paramaribo 39.5 per cent of the infested premises surveyed had infestations of the interrelated types (categories 3, 4, and 5), as shown in Table 8. Of the remaining independent infestations, 40.9 per cent were in roof gutters and 19.7 per cent were on the ground. This

TABLE 7—A. aegypti pupae in gutter and ground-level infestations.

<table>
<thead>
<tr>
<th>Survey area</th>
<th>No. of Infested containers</th>
<th>No. of premises with infested</th>
<th>% infested containers with pupae</th>
<th>% infested premises with pupae</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Gutters</td>
<td>Other</td>
<td>Gutters</td>
<td>Other containers</td>
</tr>
<tr>
<td></td>
<td>Larvae only</td>
<td>Total</td>
<td>Total</td>
<td>Total</td>
</tr>
<tr>
<td></td>
<td>Larvae and pupae</td>
<td>Total</td>
<td>Larvae and pupae</td>
<td>Total</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>Larvae only</td>
<td>Total</td>
<td>Larvae only</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>Larvae and pupae</td>
<td>Total</td>
<td>Larvae and pupae</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>Larvae only</td>
<td>Total</td>
<td>Larvae only</td>
</tr>
<tr>
<td>Area 1</td>
<td>2</td>
<td>3</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>Area 2</td>
<td>13</td>
<td>11</td>
<td>24</td>
<td>4</td>
</tr>
<tr>
<td>Area 3</td>
<td>16</td>
<td>7</td>
<td>13</td>
<td>12</td>
</tr>
<tr>
<td>Area 4</td>
<td>8</td>
<td>14</td>
<td>11</td>
<td>11</td>
</tr>
<tr>
<td>Paramaribo</td>
<td>29</td>
<td>32</td>
<td>61</td>
<td>30</td>
</tr>
<tr>
<td>Albina</td>
<td>6</td>
<td>16</td>
<td>22</td>
<td>51</td>
</tr>
<tr>
<td>Total</td>
<td>55</td>
<td>64</td>
<td>93</td>
<td>81</td>
</tr>
</tbody>
</table>
TABLE 8—Relationships of gutter and ground A. aegypti infestations.

<table>
<thead>
<tr>
<th>Survey area</th>
<th>Number of houses inspected</th>
<th>Number of gutter infestations</th>
<th>Percentage of houses infested</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Gutter and ground</td>
<td>Gutter (Near gutter infestation)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Total</td>
<td>Infested</td>
</tr>
<tr>
<td>Area 1</td>
<td>95</td>
<td>8</td>
<td>4</td>
</tr>
<tr>
<td>Area 2</td>
<td>104</td>
<td>21</td>
<td>14</td>
</tr>
<tr>
<td>Area 3</td>
<td>118</td>
<td>20</td>
<td>4</td>
</tr>
<tr>
<td>Area 4</td>
<td>84</td>
<td>22</td>
<td>7</td>
</tr>
<tr>
<td>Paramaribo</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(subtotal)</td>
<td>401</td>
<td>71</td>
<td>29</td>
</tr>
<tr>
<td>Albina</td>
<td>114</td>
<td>45</td>
<td>6</td>
</tr>
</tbody>
</table>

The pattern was most striking in area 2, where 66.7 per cent were independent roof gutter infestations; and it was also evident in area 4, where 31.3 per cent of all infestations were of this type. These findings tend to indicate that in areas 2 and 4 the infestations were spreading from the roof gutters to the ground.

However, different patterns were found in areas 1 and 3. In area 1 the two types of infestation were completely independent and there was no evidence of any movement from one type to the other. In area 3 all categories were about the same size, a finding that could indicate movement in both directions.

A different pattern was also found in Albina. Here 46.7 per cent of the infested premises had independent ground infestations, while only 13.3 per cent had independent gutter infestations. This indicates that the infestation might have been spreading from the ground to the roof gutters.

A comparison of the infestations in Albina and Paramaribo is very useful in showing the importance of roof gutters. After almost a year's lapse in treatment, and with a very high rate of infestation, the situation in Albina can be considered typical of an untreated A. aegypti population. When the data are examined, a striking similarity is found between some of the Albina figures and the average figures for Paramaribo. As shown in Tables 1, 4, and 6, the percentage of houses with roof gutters (66.1 vs. 62.3) is similar, as is the percentage with wet roof gutters that are infested (31.5 vs. 31.3), the percentage of roof gutters with water that are infested (7.4 vs. 10), and the percentage of houses with roof gutter infestation (11.7 vs. 13.2). Because of this great similarity, it must be concluded that the roof gutter infestation in Paramaribo is typical for Surinam, and that the main difference in the two localities is that the level of ground infestation has been reduced in Paramaribo. There is no evidence of A. aegypti being driven to the roof gutters by treatment in Paramaribo.

SUMMARY

In 1972 a study was made of Aedes aegypti habitats in Surinam. This was based on a comprehensive survey of all potential habitats in four areas of the capital, Paramaribo, and in part of the town of Albina.

A. aegypti larvae were found in storm sewer catch basins, but not in large numbers, although Culex fatigans infestations were very common there.

In Albina stored water was a major source of infestations, but not in Paramaribo. This was probably due to Paramaribo's ban on water storage and its A. aegypti eradication program.

It was found that roof gutters constituted a major habitat of A. aegypti in all areas surveyed. In fact, the proportion of houses with infested roof gutters in the treated areas of Paramaribo and in Albina, where treatment had
lapsed, were very similar. The main differences in infestation patterns were those due to higher levels of ground infestation in Albina.

Evidence provided by the presence of pupae at some sites and by the spatial relationship of gutter and ground infestations indicates that roof gutters are harboring numerous reservoir foci of *A. aegypti*. There is no evidence that *A. aegypti* are being driven to the roof gutters by insecticide treatments. Rather, the number of ground infestations appears to have been reduced in treated areas, leaving the gutter infestations relatively unaffected.

REFERENCES


