Importance of domestic water containers as *Aedes aegypti* breeding sites in Suriname; implications for dengue control

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**Abstract**

Entomological surveys were done in five communities divided over four districts in Suriname in order to assess *Aedes* spp. larval indices in communities at risk for dengue transmission and to determine key *Aedes* breeding sites. During the surveys, potential and positive *Aedes* sp. mosquito breeding sites (water-holding containers) were identified and recorded. The containers were categorized according to various types, and larval indices - Breteau index, House index, and Container Index - were calculated. Based on the frequency of positivity for *Aedes* spp. larvae, a key container type for *Aedes* spp. breeding was identified. A total of 1,105 houses was (re-)visited between May and August 2012. The calculated indices showed that all five communities were dengue-sensitive. The Breteau index (number of positive water containers per 100 houses) of four of the five communities indicated a high dengue transmission risk and ranged from 105.7 to 346.6. The container type most frequently found positive was ‘water storage container’. All mosquito samples taken from positive containers were identified as *Aedes aegypti*. It can be concluded that the abundance of household water storage containers in the communities results in a high dengue transmission risk. National dengue control activities should include measures to reduce key breeding sites in the communities. Environmental management with community participation is advised. Increased access to piped water supply should be promoted.

**Keywords:** *Aedes aegypti*, water containers, dengue control, Suriname

**Introduction**

The national battle against dengue in Suriname was initiated in the first decade of the last century when more elaborate use of bed nets was adopted and when, after the epidemics of 1908/1909, a mosquito squad was charged with the elimination of breeding sites in yards. Since then, dengue and mosquito control included legislation on sanitary conditions of yards (1912), treatment of water receptacles with DDT (1948), and spraying (from 1949 onwards) with DDT, Dieldrin, gammaxane, fenithion, and Baytex (van der Kuyp, 1967). Dengue control profited from yellow fever and malaria control activities. However, the regional program initiated by the Pan American Health Organization to eradicate *Aedes aegypti* and to control yellow fever and dengue, failed to reach its objective in Suriname. This was partially attributable to resistance of the mosquitoes to the insecticides employed. Its initial success in several Latin American countries was soon undone by re-infestation from areas where eradication had not been achieved (Vasconcelos et al., 1999). From the 1970s onward, control measures in Suriname included the perifocal spraying with malathion and fenithrothion and control of larvae with temephos (Abate). In 2011, Bti-formulation (*Bacillus thuringiensis israelensis*) was introduced for larval control. Still, *Aedes aegypti* mosquitoes are abundant and dengue epidemics are a recurrent event, the most recent one reported in the first months of 2012.
In populated areas, *Aedes aegypti* mosquitoes breed primarily in artificial water containers. Since there is no curative treatment for dengue, targeted environmental and ecosystem management is important. Worldwide, the results of general community clean-up campaigns or space-spray application of insecticides were often disappointing due to their limited effect on disease incidence (WHO, 2012). A more targeted, evidence-based approach to mosquito control is required, which makes entomological surveys an indispensable part of control programs.

Commonly used entomological dengue risk assessment tools are the larval indices. The Breteau Index (BI; the number of positive containers per 100 houses) is the most widely used and is thought to predict changes in dengue transmission risk, although its critical threshold seems to depend on local circumstances (Sanchez et al., 2006, 2010). The use of larval indices for dengue risk assessment is controversial. The House Index (HI; the percentage of houses positive for larvae) does not take into consideration the number of positive containers per house. Similarly, the Container Index (CI; the percentage of containers positive for larvae) does not relate the proportion of water-holding containers that are positive to the number of houses. Since the BI establishes a relationship between positive containers and number of houses, it is considered the most useful index for predicting (changes in) transmission risk in a location (WHO, 2011). Currently, the focus of entomological surveillance in dengue control programs is shifting towards the use of the pupal index (PI; the number of pupae per 100 houses) as this may be more appropriate for assessing dengue risk and to direct control operations (Focks and Chadee, 1997, WHO, 2011). However, one of the problems encountered with this method is its labour-intensive development of efficient and cost-effective adult surveillance methods would be advantageous for surveillance and control programs (Tun-Lin et al., 1996).

In the contexts of the need for targeted vector control, tools known as ‘key container’ and ‘key premise indices’, aiming to identify the container types and localities most frequently found positive for *Aedes* larvae, have been developed (Nam, 2003). The limitation of working with larvae is that a container type infested with larvae does not necessarily produce most adult mosquitoes. The production of adults depends on larval density and larval mortality. Finding the container with the highest pupal density may provide a more realistic picture, but again this will require a significant amount of labour.

Entomological surveillance of *Aedes* sp. mosquitoes in Suriname has been limited in the last decades. Very little information exists on characteristics of the mosquito populations (e.g., seasonality, vector capacity, insecticide resistance, and primary breeding sites) and on the efficiency of mosquito control measures. In this study, we report on the first more elaborate entomological *Aedes* surveys in Suriname since many years. Our objective was to get an indication of *Aedes* breeding sites on the premises of people’s houses and to identify the key container for *Aedes* breeding in five communities in the country. Considering the available human capacity, it was decided to work with the traditional larval indices.

**Materials and methods**

Between May and August 2012, entomological surveys to determine larval indices and to identify key breeding sites of *Aedes aegypti* mosquitoes were done in Flora, a neighbourhood of Suriname’s capital Paramaribo (district Paramaribo), in Marienburg and Zoelen (district Commewijne), in a selected part of Domburg (district Wanica), and in Albina (district Marowijne) (Figure 1). During house-to-house visits and with consent of the owners, all water-holding containers were inspected for the presence or absence of *Aedes* sp. larvae. Whenever the owners were not present or not inclined to cooperate, the houses were excluded from the survey. Potential water containers above the reach of the investigators such as roof gutters were not included in the study. At selected sites, small samples of the larvae were collected to be bred to adults and identified.

![Figure 1. Coastal area of Suriname with survey localities; Flora (A; district Paramaribo), Domburg (B; district Wanica), Marienburg and Zoelen (C; district Commewijne), and Albina (D; district Marowijne).](image-url)
In Marienburg and Zoelen, an effort was made to make the public aware of the risk of having larval breeding sites on the premises, and to provide information on ways to dispose of or prevent breeding sites. The entomological survey in these two locations was repeated after two weeks.

Results

Overall, 1,105 houses were (re-) visited during the entomological surveys. In the Flora neighbourhood, *Aedes* sp. larvae were found on 48 of the 183 premises surveyed. In Domburg, 822 potential breeding sites were encountered, nearly 300 of which were infested with *Aedes* sp. larvae. Of the 280 premises surveyed in this location, 133 were positive. In Albina, 147 premises were surveyed of which 101 were positive. The summarized results and larval indices for these three locations are given in Table 1. The calculated indices indicate a high dengue transmission risk in the study locations.

### Table 1. Summarized results of larval *Aedes* surveys at Flora, Domburg, and Albina

<table>
<thead>
<tr>
<th>Location</th>
<th>Survey 1</th>
<th>Survey 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of houses inspected</td>
<td>183</td>
<td>280</td>
</tr>
<tr>
<td>Number of houses positive</td>
<td>48</td>
<td>133</td>
</tr>
<tr>
<td>Number of containers found</td>
<td>122</td>
<td>822</td>
</tr>
<tr>
<td>Number of containers positive</td>
<td>76</td>
<td>296</td>
</tr>
<tr>
<td>House index</td>
<td>26.2</td>
<td>47.5</td>
</tr>
<tr>
<td>Container index</td>
<td>62.3</td>
<td>36.0</td>
</tr>
<tr>
<td>Breteau Index</td>
<td>41.5</td>
<td>105.7</td>
</tr>
</tbody>
</table>

In Marienburg and Zoelen, the number of houses visited during the second survey was slightly lower than the number visited during the first survey. This was partly due to recent rainfall, which had made some yards inaccessible. Many houses and premises in Marienburg and Zoelen are built just above ground water level. Flooding of the yards after rainfall is common.

Table 2 summarizes the results and larval indices for Marienburg and Zoelen for both survey 1 and 2.

### Table 2. Summarized results of larval *Aedes* surveys at Marienburg and Zoelen (survey 1 and 2).

<table>
<thead>
<tr>
<th>Location</th>
<th>Survey 1</th>
<th>Survey 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of houses inspected</td>
<td>193</td>
<td>175</td>
</tr>
<tr>
<td>Number of houses positive</td>
<td>162</td>
<td>144</td>
</tr>
<tr>
<td>Number of containers found</td>
<td>1,278</td>
<td>840</td>
</tr>
<tr>
<td>Number of containers positive</td>
<td>669</td>
<td>517</td>
</tr>
<tr>
<td>House index</td>
<td>83.9</td>
<td>82.3</td>
</tr>
<tr>
<td>Container index</td>
<td>52.4</td>
<td>61.5</td>
</tr>
<tr>
<td>Breteau Index</td>
<td>346.6</td>
<td>295.4</td>
</tr>
</tbody>
</table>

The mosquito larvae which were bred to adults were all identified as *Aedes aegypti* mosquitoes.

![Figure 2. Domestic water storage containers are key *Aedes* spp. breeding sites in the surveyed localities.](image)

Discussion

The BIs found in the surveyed communities were consistent with a relatively high dengue sensitivity of the study sites (BI > 20, WHO 1995). Indeed, except for that of Flora, all BIs were above 50 which is an indication for high dengue transmission risk. BIs for Marienburg and Zoelen were above (first survey) or just below (second survey) 300. Apparently, during the second survey the BI was in the same range as during the first survey, even though the community had received information on the breeding sites problem and on ways to prevent or solve it.
The key containers in all communities, identified based on the presence of larvae, were the water storage containers. Many houses had a variety of water storage containers on the premises. This was most likely directly related to the limited access to piped water supply in these communities. To assess whether or not the water storage containers were the most productive breeding sites for *Aedes* mosquitoes, further investigations such as determination of pupal indices are necessary. Still, in comparable situations in Trinidad, outdoor water drums, tubs, buckets, and basins were the most frequent breeding sites, and they were responsible for the majority of pupae produced (Focks and Chadee, 1997; Chadee, 2007).

The current focus of dengue vector control in Suriname is on aerial and perifocal spraying with malathion and fenithion. Efforts are also made to reduce disposal of solid waste and garbage in the community environment via interventions of the Ministry of Public Works and through interaction with the communities. Our study shows that household water storage containers constitute a significant threat to the communities by providing breeding opportunities to *Aedes* mosquitoes. This important finding needs to be taken into account in the national dengue control program. The program could apply the entomological surveillance data to reduce costs and make more efficient use of manpower and equipment by concentrating efforts on eliminating key *Aedes* breeding sites.

Breeding site reduction is an important preventive measure in communities with high BIs. The most productive types of breeding sites should be removed, destroyed or altered to prevent further breeding. Evidence exists that community-based environmental management can have a significant impact on mosquito populations and dengue transmission. During the dengue outbreak in Santiago de Cuba in 2006-2007, for instance, there were selected house blocks where community working groups implemented plans with the local populations to reduce *Aedes* infestations. The number of house blocks without dengue was higher and the number of dengue fever cases in affected blocks was lower than that in control areas where routine vector control activities were employed (Toledo et al., 2011). It is evident that elaborate community education and behavioural change communication will be needed to accomplish this.

Water storage containers are identified as key breeding sites. Improved access of the communities to piped water supply will reduce the need for these containers and needs to be promoted. Additionally and in the meantime, biological larval control measures could be applied. Incidental use of larvivorous fish in water wells was observed in Marienburg. More elaborate use of this control measure could be advantageous, as was shown elsewhere (Seng et al., 2008; Chandra et al., 2008).

The importance of *Aedes* control is increasing with the added regional threat of the Chikungunya virus, which is also transmitted by *Aedes* mosquitoes (PAHO, 2011). Development of an integrated and focused package of control measures which includes environmental management (where necessary aided by legislative measures), biological control, and community education and involvement will help reduce the need for insecticide use. A study by Rawlings (1998) showed that in 1995/1996 *Aedes aegypti* populations in Suriname were still sensitive to malathion and temephos. Recent tests for the *Aedes* population in Paramaribo confirm this status for malathion (unpublished results). However, when considering the regional emergence of insecticide resistance in *Aedes* mosquitoes, a careful and evidence-based use of vector control measures, including the use of insecticide, is recommended.

**Acknowledgements**

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**References**


