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Impact of pre-seasonal focal treatment on population densities of the mosquito *Aedes aegypti* in Trinidad, West Indies: A preliminary study

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ABSTRACT

A new pre-seasonal focal treatment strategy against *Aedes aegypti* L. (Diptera: Culicidae) mosquitoes is described for the first time. It was evaluated for 25 weeks using ovitraps, and larval and pupal surveys in the townships of Curepe (treated) and St. Joseph (untreated), Trinidad, West Indies. Both townships were similar with respect to number of houses, size of human populations, the number of *Ae. aegypti* infested houses and containers. In March 2003, a total of 9403 containers were inspected, of which 1.4% in Curepe (63/4499) and 1.3% in St. Joseph (64/4904) were positive for *Ae. aegypti* immature stages. Curepe had a lower percentage (12.7%) of the main type of breeding container present (small miscellaneous containers) than St. Joseph (28.1%). Following focal treatment during the month of April (2–3 weeks before the onset of the rainy season), the *Ae. aegypti* population declined significantly ($P > 0.01$) from a Breteau index (BI; proportion of containers positive for larvae and pupae) of 19.0 to a minimum of 6.0 and a pupae/person index (PI) of 1.23 to a minimum of 0.35 in May, while in the untreated town of St. Joseph, the BI steadily increased from 23 to 38 and the PI rose from 0.96 to 2.00 in August. Similar declines in other measures of population density (the number of positive houses and number of eggs collected in ovitraps) were observed in Curepe, while St. Joseph maintained PI of >1.50 and BI of >28. Furthermore, the Curepe *Ae. aegypti* population did not return to pre-treatment levels until 9–11 weeks after treatment, far beyond the 6 weeks normally expected during vector suppression campaigns. The results suggest that timely application of pre-seasonal focal treatment with temephos together with standard control measures, such as source reduction of the most productive containers, can reduce the Breteau index to <5 and the pupae/person index to <0.71 (i.e., below the suggested dengue transmission thresholds for Trinidad), and extend the duration of vector suppression.

1. Introduction

In Southeast Asia and in the Americas many workers have reported a positive correlation between high densities of *Aedes aegypti* (L.) and high incidences of dengue fever cases with peak rainfall (Gould et al., 1970; Chadee et al., 2004, 2005). These data suggest that seasonal outbreaks are predictable to some extent, but vector control efforts are generally implemented in response to epidemics, with the mobilization of community source reduction and health promotion campaigns long after the period when these interventions would be most effective (Rosenbaum et al., 1995). As demonstrated by a recent study in Trinidad, when, routine vector control failed to prevent epidemic outbreaks of dengue fever (Chadee et al., 2005). Taken together, these studies suggest the need for a more systematic approach to vector control and for better understanding of, and preparation for, epidemics by strategic management of resources during routine vector control operations (Rosenbaum et al., 1995; Chadee et al., 2005).

Vector control programmes in the latter half of the 20th century have relied on a suite of vector control applications, ranging from traditional vector control to community participation; including environmental source reduction, adult-mosquito control using space spraying, intradomicillary spraying, larval control of only positive containers through focal treatment (systematic application of insecticides directly inside containers in accordance with its holding capacity), health education campaigns, and more recently the COMBI (community-based intervention) (PAHO, 1994; Banerji, 2004). Each approach has merits and collectively can achieve significant levels of vector suppression, but this combination of approaches has failed largely because of changes in demographics, climate, householder's attitudes, practices and beliefs, management styles, globalization and unionization of workers (Gubler and Kuno, 1997; Rosenbaum et al., 1995; Troyo et al., 2006; Chadee et al., 2007).

Gubler and Clark (1996) advocated the need to shift from traditional chemical control to a community-based source reduction

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approach, but enthusiasm for this approach has not been sustained and therefore provides at best only a modicum of short-lived suppression of the vector (Leontsini et al., 1993; Service, 1993; Focks et al., 2000).

The minimum population density of *Ae. aegypti* required for successful transmission of dengue fever is still not fully understood. Simulation models indicate that the dengue transmission threshold is a function of many factors, but the key determinants appear to be the number of pupae/person, the number and size of viral introductions during the year, seroprevalence of dengue antibody and temperature (Focks et al., 2000). However, the goal of vector control usually has a single focus; to reduce the mosquito population to below the 'disease transmission threshold' which is thought to be a Breteau index of 5 (as developed for yellow fever by Macdonald, 1956) or 0.71 pupae per person (Focks et al., 2000).

Studies on climate variability and dengue transmission have led to the development of early warning systems based on the predictability of the dengue season. However, there has been little research on pre-emptive strike modalities, with the exception of efforts to identify a vaccine, which may still be decades away from success.

The present study was conducted to test the efficacy of a new approach to the control of *Ae. aegypti*, which aims to reduce populations during periods of anticipated rapid increase in population density, as predicted by dengue early warning systems. Hence, the effect of pre-seasonal focal treatment (application of focal treatment in all potential breeding habitats before the onset of the rainy season) on the population density of *Ae. aegypti* during the first 2 months of the rainy season was investigated.

2. Materials and methods

2.1. Study sites

This study was conducted for 25 weeks from 1 March to 31 August 2003 in two major housing areas located along the east–west corridor (Chadee, 2004) in north Trinidad: Curepe (10°42′N: 60°24′W), a semi-urban area with approximately 3000 houses and 15,000 people and St. Joseph (10°40′N; 60°25′W), an urban housing centre nestled upon the lower southern slopes of the northern range of mountains with approximately 1500 houses and 9000 people. Both localities are endemic for dengue fever and support large populations of *Ae. aegypti* mosquitoes (Chadee, 2004). The rainy season (May–November) usually begins in May, when peak mosquito and dengue incidence occur (Chadee et al., 2007).

2.2. Study design and ovitrapping

Baseline data on *Ae. aegypti* population densities in St. Joseph and Curepe were collected for 1 year (2002) by ovitraps (Fay and Eliason, 1966) as described by Chadee and Corbet (1987). Each ovitrap consisted of a cylindrical, black, glass jar (height 13 cm, diameter 6 cm) containing about 375 mL of tap water and a removable "paddle" (a thin strip of brown hardboard, 12.5 cm × 2.5 cm) on which the mosquitoes laid eggs just above the water level. There was no overflow hole in the side of the jar.

In 25 selected houses in Curepe, 50 ovitraps were set with the identical number of ovitraps being placed in 25 houses in St. Joseph. Two ovitraps were placed in each of the monitoring houses in both towns as follows: both traps were placed at 1.2 m above ground level, one indoors, behind the couch in the living room and the other outdoors on the porch. All ovitraps were serviced weekly as described by Chadee (1991).

Similar seasonal patterns were found in both areas, with a significant ($P > 0.002$) increase in the number of *Ae. aegypti* eggs (pooled

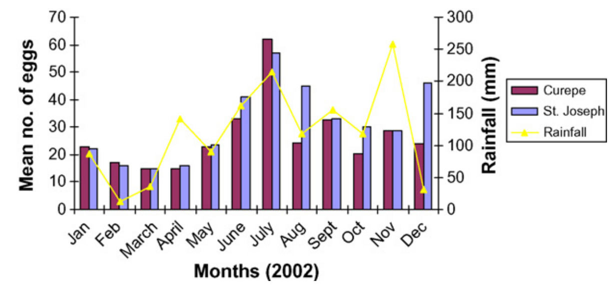

Fig. 1. The monthly rainfall and mean number of *Ae. aegypti* eggs collected in ovitraps in Curepe and St. Joseph, Trinidad (2002).

data due to large variation in total number of eggs collected per trap) after the onset of the rainy season in late April/early May 2002 (Fig. 1). Neither of these sites was treated with insecticides during the sampling period.

The following year, the impact of pre-seasonal (i.e. before the onset of the rainy season) insecticidal applications to all positive and potential *Ae. aegypti* breeding sites was evaluated at the two study sites. In Curepe, 120 houses were selected for treatment, and the same numbers of houses in St. Joseph were selected to be the untreated controls. In March 2003 ovitraps were set up to monitor the *Ae. aegypti* population density in 20 of the selected houses in each town, for the next 25 weeks. In May 2003, 4 weeks before the onset of the rains, all 120 selected houses in Curepe were inspected and focally treated with insecticides, while the selected houses in St. Joseph were inspected but not treated.

Ovitraps were exposed for 1 week for each of 25 weeks. Each week, paddles labeled with house number and location (inside or outside) were removed and replaced by egg-free paddles, the water in each ovitrap discarded, ovipot scrubbed to remove any eggs laid or attached to the inside of the ovitraps (Chadee et al., 1995) and 350 mL of fresh tap water added. The handling of paddles and identification of eggs after collection have been described by Chadee (1991).

Oviposition patterns were analyzed for the dry season (March–April 2003), for the wet season (May–July 2003) and for both periods combined. Oviposition activity was recorded as the weekly 'mean proportion of ovitraps with eggs' and 'mean number of eggs per ovitrap' in indoor and outdoor locations. Data were transformed into (5 × 4) contingency tables and analyzed using a *G*-test (Sokal and Rohlf, 1980). In addition, the mean numbers of eggs per ovitrap were transformed ($\sqrt{1+x}$) and an analysis of variance (ANOVA) performed (Sokal and Rohlf, 1980).

2.3. House inspections and treatment

During March 2003 all of the natural and artificial containers in the selected 120 houses and the compounds surrounding these houses in Curepe were inspected by the laboratory staff of Insect Vector Control Division, Ministry of Health using the Pan American Health Organization guidelines (PAHO, 1968) as follows: all indoor and outdoor containers within 25 m of each house, including natural habitats such as tree holes and leaf axils, which might harbour *Ae. aegypti* and other mosquitoes, were inspected to determine whether they were wet or dry and for the presence or absence of *Ae. aegypti* immatures (larvae or pupae). Containers located in dark or shaded areas were inspected using flashlights. Samples from each positive container were collected using ladles and pipettes, placed in phials, labeled, recorded on standard forms and sent to the Insect Vector Control Division laboratory where they were identified or the pupae allowed to emerge and adults identified using appropriate taxonomic keys.