

Absence of impact of aerial malathion treatment on *Aedes aegypti* during a dengue outbreak in Kingston, Jamaica

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ABSTRACT

During an outbreak of dengue fever in Jamaica from October to December 1995, a study was carried out to determine the impact of aerial ultra-low volume malathion treatment on adult *Aedes aegypti*. This was done by monitoring oviposition rates of the vector in three urban communities in Kingston and by exposing caged mosquitoes both directly and indirectly to the aerial malathion treatment. The insecticide was delivered at a rate of 219 mL/ha between 7:10 a.m. and 8:45 a.m. The results of the study clearly showed that the insecticide application was ineffective in interfering with *Aedes aegypti* oviposition, and adult mosquitoes held in cages inside dwellings were largely unaffected. Consequently, this type of intervention seemed to have little significant impact in arresting or abating dengue transmission.

Aedes aegypti is the only known vector of dengue, dengue hemorrhagic fever (DHF), and dengue shock syndrome in the Caribbean, and the virus and its vector have challenged the well-being of the Caribbean people, as well as the vital tourist trade on which

nearly all the countries of the area rely (1–6).

Public health authorities in the Caribbean have advocated managing this mosquito at its source by eliminating containers that harbor *Ae. aegypti*. In the case of nondisposable containers (7), insecticide use has been recommended and instituted in most of the 21 countries that belong to the Caribbean Epidemiology Center (CAREC), an institution affiliated with the Pan American Health Organization and that provides laboratory reference and epidemiology services to the CAREC Member Governments.

While the primary approach to *Ae. aegypti* management in the Caribbean continues to be source reduction, if *Ae. aegypti*-transmitted disease occurs, environmental management has obvi-

ously been inadequate and swift measures are required to limit transmission. In order to control a dengue epidemic, Giglioli (8) postulated the need for an immediate minimum 97% reduction of adult *Ae. Aegypti*. One way to do that may be with such rapid adulticidal measures as ultra-low volume (ULV) sprays (9). In an emergency, aerial and ground ULV applications of insecticides could quickly disperse the toxicants over a wide geographic area.

Gubler (10), however, expressed little faith in the effectiveness of ULV applications on wild *Ae. aegypti* populations. Conversely, Gratz (9) argued that ULV applications of insecticide during disease outbreaks appeared to be the only measure available for emergency control of *Aedes* vectors in

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most urban and periurban areas. There are several instances of aerial ULV application of malathion for *Ae. aegypti* control which were deemed successful, as in the case of Uribe et al. (11) in Buga, Colombia, and Perich et al. (12) in the Dominican Republic. On the other hand, there are instances where aerial applications had to be repeated to obtain the desired effect (13, 14). Dosage, droplet size, conditions of applications, the physical environment, and basic susceptibility of the host mosquito could all affect the impact of the ULV treatment.

The only previous experience with aerial ULV malathion treatment for *Ae. aegypti* control in the English-speaking Caribbean was in the 1977 dengue/DHF epidemic in Jamaica. Moody et al. (15) reported a 70–100% bioassay success on caged *Ae. aegypti* when 96% technical grade of malathion was applied in the main urban areas of the country, using single-engine aircraft and truck-mounted equipment. Because of this measure of apparent success in the 1977 epidemic and despite the expressed reservations of the local scientists, the Ministry of Health of Jamaica considered it worthwhile to intervene in a 1995 epidemic with aerial ULV malathion treatments.

On 6 October 1995 the Ministry of Health officially informed the Jamaican public of a dengue fever outbreak in the country. The Ministry then launched a major dengue control program, emphasizing public education, community mobilization, and clean-up campaigns. Over the course of the epidemic in 1995, a total of 1 884 suspected cases were reported, including 108 cases of dengue hemorrhagic fever, 3 cases of dengue shock syndrome, and 4 deaths.

On 8 November 1995, aerial ULV malathion spraying was done in the metropolitan Kingston and St. Andrew area, which consists of the capital city of Kingston and the urban portion of the adjacent parish of St. Andrew. In an assessment carried out by this study's authors of the spraying's effect on caged *Ae. aegypti* mosquitoes at three outdoor sites, there was 100% mortality

at two of the sites, and 50% died at the third site. At nine indoor or partly indoor sites all the mosquitoes survived the treatment. Thus the effectiveness of the aerial spraying was considered relatively low and brought into question the value and cost of the operation.

Despite its likely limited impact, a second treatment was scheduled for 19 November 1995. Since a scientific evaluation of the effectiveness of aerial ULV malathion intervention could be extremely useful for future requests by Caribbean and other vector control authorities for appropriate tools for rapid response to a dengue epidemic, the present study was designed and executed.

The impact of aerial ULV malathion on the *Ae. aegypti* populations was assessed by monitoring oviposition rates in three sections of Kingston: Hughenden, Richmond Park, and Vineyard Town. At the same time, adult mosquito bioassays were used to assess the penetrative action of the aeri ally dispersed malathion, as well as the extent of the insecticidal coverage.

The Kingston/St. Andrew urban area is densely populated and has over 800 000 residents, with concrete and wooden homes that are generally close to each other. There is also a large amount of vegetation between homes, which could affect the penetration of ULV droplets into residences and thus the insecticide's impact on the endophilic *Ae. aegypti* mosquitoes.

To study oviposition rates, paired enhanced oviposition traps (16) containing 4-day-old hay infusion were

used for daily (24-hour) egg collection at 30 preselected residences in each of the three study areas. Egg collections were made on seven consecutive days: the two days before the aerial spraying, the day of the spraying (19 November 1995), and the next four days. The mean egg production per site-day was calculated. Daily servicing of the ovitraps was done between 9:00 a.m. and 11:00 a.m.

Adult mosquito bioassays were done with cages holding 3-day-old female *Ae. aegypti* that were exposed either directly or indirectly to the insecticidal treatment at seven widely distributed sites that were selected randomly and were considered as representative of the entire Kingston/St. Andrew area. The bioassay cages were retrieved and returned to the laboratory 1 hour after the completion of the spraying operations.

On 19 November 1995 the Kingston/St. Andrew metropolitan area was treated with 95% malathion applied by two Thrush Commander S2R aircraft, flown at a height of 30 to 45 meters and a speed of 192 km/h. The insecticide was delivered at a rate of 219 mL/ha (3 fluid ounces per acre), with aerosol droplet size estimated at 10–15 microns. Spraying was done between 7:10 a.m. and 8:45 a.m. The meteorological conditions seemed conducive to aerial spraying, with a mean wind speed of 5.6 to 9.3 km/h and a mean temperature of 26.4 °C.

The data from the bioassay of caged mosquitoes (Table 1) showed that

TABLE 1. Mortality (percent) of caged adult female *Aedes aegypti* mosquitoes following aerial ULV spraying with malathion, Kingston, Jamaica, November 1995

Sentinel station	Indoor cage	Outdoor cage
1. Harbour View	0	0
2. Pembroke Hall	0	88
3. Cherry Gardens	0	12
4. Hope Pastures	7	29
5. Eastwood Park	71	56
6. Passmore Town	0	100
7. National Public Health Lab. Control	—	100
	0	—

mortality in seven outdoor cages was variable and reasonably good, ranging from 12% to 100%, except in the Harbour View area, where the mosquitoes were unaffected by the aerial ULV spraying. There was a mean 55% kill. Conversely, the mean mortality rate in six indoor mosquito cages was a mere 13%, ranging from 0% to 7% in five of the sites and reaching a high of 71% in just the bioassay cage at Eastwood Park.

The high prevalence of gravid *Ae. aegypti* in all three study areas was a remarkable determinant feature of the dengue epidemic in the Kingston area. For example, on 19 November, the day of aerial ULV spraying, 62% to 72% of the homes with ovitraps were positive for *Ae. aegypti* eggs. In two of the three study areas the proportion of homes with positive ovitraps continued to rise after the intervention. The rate subsequently went as high as 93% (Figure 1). In a similar manner, there was no dramatic overall reduction in the number of eggs of *Ae. aegypti* per house per day deposited after the ULV sprays (Figure 2).

The epidemic peaked in the Kingston/St. Andrew metropolitan area around the week of 18 November, that is, two weeks after it peaked in the rural parishes. In both areas, the peak was followed by a marked decline (Figure 3). After the first aerial treatment, on 8 November, the epidemic continued its upward trend in Kingston and St. Andrew for the next 10 days. There was then an abrupt decrease in reported cases beginning on or about the date of the second aerial application, 19 November. The decline continued for the next two weeks, followed by a sharp, brief rise and then a gradual fall.

The decision to undertake aerial ULV malathion spraying was based on an assumption the treatment would rapidly reduce the adult *Ae. aegypti* population by at least 97%, as postulated by Giglioli (8), with a concomitant fall in dengue virus transmission. The expectation, therefore, was that there would be a significant decline both in the percentage of houses with gravid mosquitoes and in mosquito egg pro-

FIGURE 1. Percentages of houses with positive ovitraps, Kingston, Jamaica, November 1995

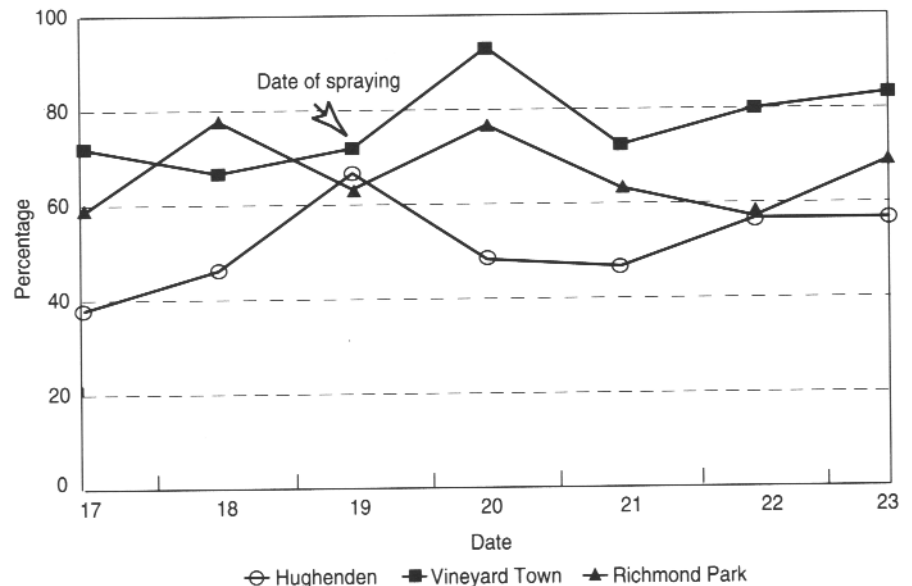
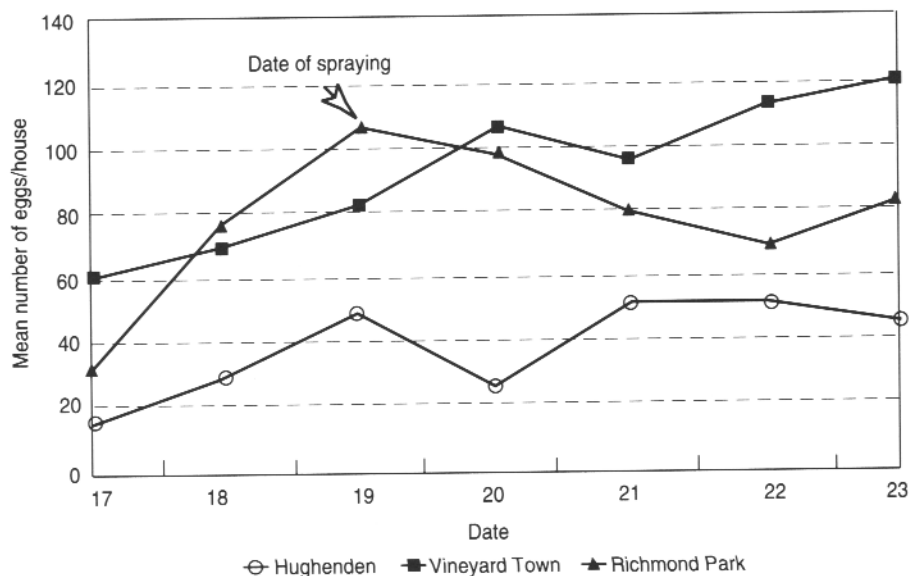


FIGURE 2. Mean number of eggs per house per day, Kingston, Jamaica, November 1995

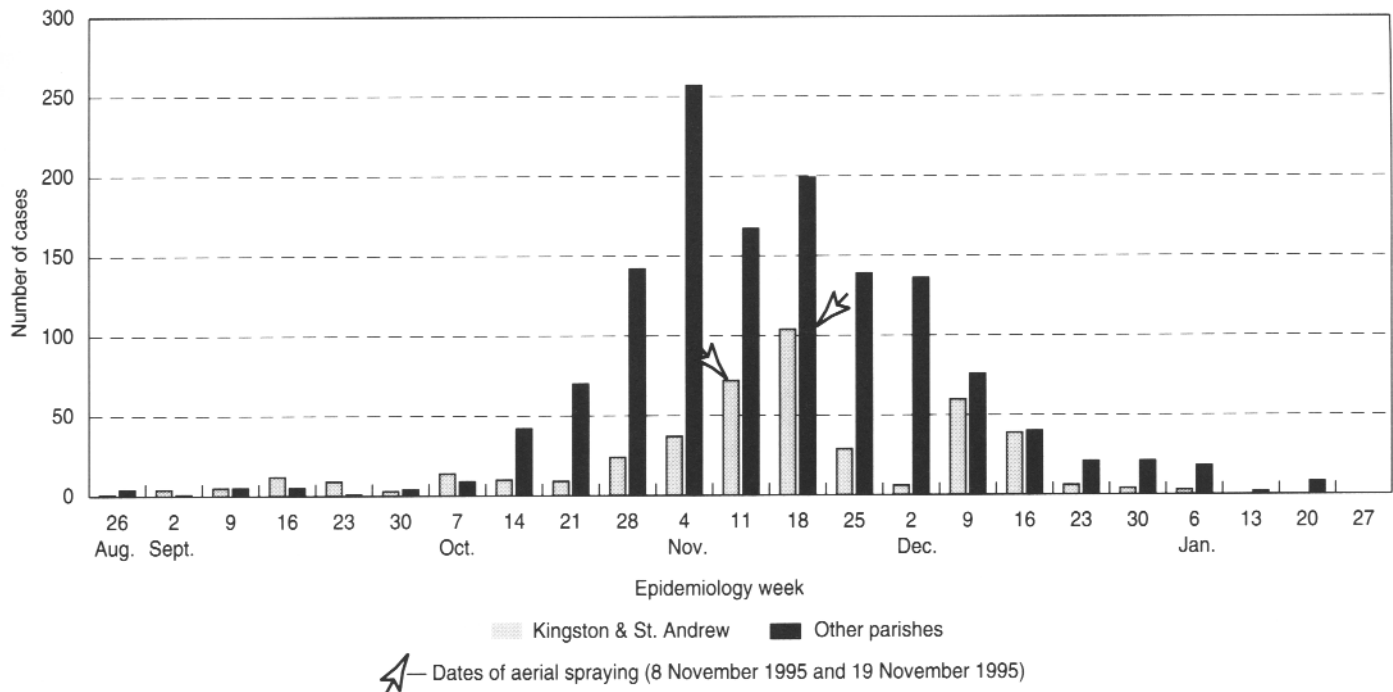


duction following treatment. However, the results of this study clearly demonstrated that the insecticidal intervention proved ineffective in interfering with *Ae. aegypti* oviposition activity.

The mortality of caged mosquitoes was unimpressive in both the outdoor

locations (mean kill of 55%) and the indoor ones (mean kill of 13%). Therefore, it was not surprising that there was no impact after the intervention on either the oviposition rate or the proportion of homes found positive for gravid *Ae. aegypti*. In the aerial

FIGURE 3. Reported cases of dengue, Kingston/St. Andrew vs. other parishes in Jamaica, August 1995–January 1996



spray treatment of Kingston in 1977, Moody et al. (15) reported 70–100% mortality, which was thought to have affected the outcome of the epidemic. However, because of simultaneous ground and aerial ULV treatments, it was not possible to specifically determine the impact of aerial ULV treatment on the *Ae. aegypti* population.

Closer examination of the results of other aerial ULV interventions, such as Perich et al. (12), indicated that after single spray treatments, fairly good mortality of *Ae. aegypti* was obtained outdoors, but little or no impact was detected at various indoor locations. Repeated aerial sprays were effective in Buga, Colombia, (11) and the southeastern United States of America (13). In the latter case, it took a twice-weekly treatment regime of 35.5 mL/ha of malathion over an 11-week treatment period (22 treatments total) to completely interrupt *Ae. aegypti* oviposition, a goal not achieved with the two Kingston/St. Andrew aerial applications 11 days apart. Thus, repeated or sequential aerial treatment may prove successful over a period of time. But

such success still would not meet our current requirement of rapid interruption of the *Ae. aegypti* population in order to break the ongoing dengue epidemic.

Another issue that may have affected the outcome of the present intervention is dosage. The second Kingston/St. Andrew spraying used only 219 mL/ha, though as much as 682 mL/ha was found to be effective in Buga, Colombia (11). This high dosage contrasted with the 50 mL/ha permitted in the United States (9). In Jamaica, there were no legal limits on the dosage, but the public's tolerance of the malathion was an important consideration. The unpleasant smell of higher dosages of malathion may have contributed to the residents' failure to open their doors and windows early in the morning, thus limiting the penetration of the chemical and the impact on the endophilic mosquitoes. In addition, the impressive vegetational cover which characterizes much of Kingston and St. Andrew could have caused the entrapment of a fair quantity of the insecticide droplets in their descent to

the targeted sites. These possibilities are supported by the results obtained from bioassays of adult mosquitoes in indoor cages.

We do not believe that reduced sensitivity to insecticides was an important factor in the failure of these control efforts. In comparison to a mosquito strain kept at the CAREC facilities in Trinidad for 16 years without exposure to any chemicals, the Hughenden and Richmond Park strains of Jamaica larval *Ae. aegypti* only showed 3.5 and 2.5 resistance ratios respectively to temephos (17, 18). The Jamaican strains were among the Caribbean populations most sensitive to the organophosphate insecticide. Against malathion, adult Richmond Park and Hughenden strains only showed 2.2 and 3.6 resistance ratios respectively in comparison to the same susceptible CAREC strain (18).

The dengue surveillance data (Figure 3) could imply an effect of aerial treatment on transmission. However, this conclusion is definitely not supported by the entomological evaluation and may therefore be artifactual.

The fall in reported cases in the Kingston/St. Andrew metropolitan area coincided with a waning epidemic in the rural parishes, which had not been subjected to air sprays. This suggests the effect of a factor unrelated to aerial spraying: the increasing dengue-immune status of the human population.

As the expression says, "Dead mosquitoes don't lay eggs!" Nevertheless, this study has demonstrated that aerial ULV malathion spraying exerted no adverse effect on the oviposition rate of the adult population and consequently seemed unlikely to significantly arrest or abate dengue transmission. Given the calculated cost of

US\$ 30 000 for a morning's spray operations, it seemed unlikely that the apparent requirement of a number of sequential treatments would be attractive or possible in Jamaica or most other Caribbean countries.

The study suggests that a single aerial spray is not an effective rapid response as a control measure for dengue fever outbreaks. Sustained routine efforts by the vector control authorities and the community during interepidemic periods, such as in source reduction and environmental sanitation, are probably much more effective. They are also more economical, especially for poor countries, in preventing high prevalences of gravid

Ae. aegypti and an accompanying dengue epidemic.

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RESUMEN

Falta de impacto del rociamiento aéreo con malatión a volúmenes muy bajos en *Aedes aegypti* durante un brote de dengue en Kingston, Jamaica

Durante un brote de dengue que ocurrió en Jamaica de octubre a diciembre de 1995, se llevó a cabo un estudio a fin de determinar el impacto del rociamiento con volúmenes muy bajos de malatión en mosquitos *Aedes aegypti* adultos. Se observaron las tasas de ovipostura del vector en tres comunidades urbanas de Kingston y se expusieron mosquitos colocados en trampas directa e indirectamente a rociamientos aéreos con malatión. El insecticida se roció a una velocidad de 219 mL/ha entre las 7.10 y las 8.45 h. Los resultados del estudio claramente demostraron que la aplicación del insecticida no interfirió con la ovipostura de *Aedes aegypti*, y los mosquitos adultos colocados en trampas dentro de las viviendas casi no sufrieron ningún efecto. Por consiguiente, este tipo de intervención parece haber tenido muy poco impacto en la interrupción o atenuación de la transmisión del dengue.

Premio Abraham Horwitz en Salud Interamericana, 1999

Fecha límite: 31 de marzo de 1999

La Fundación Panamericana de la Salud y Educación (PAHEF), entidad sin ánimo de lucro colaboradora de la OPS, solicita nominaciones para el vigésimo segundo Premio Abraham Horwitz en Salud Interamericana. El premio, financiado por medio de un fondo constituido por contribuciones de amigos del doctor Horwitz, Director Emérito de la OPS, se creó con el fin de reconocer su destacado aporte a la salud de las Américas.

Este premio, que consiste en un diploma y US\$ 1 000, se ha establecido con la intención de promover la excelencia y el liderazgo en el campo de la salud entre las personas que trabajan en las Américas y cuyas ideas y labores tienen importancia regional. Se prefieren candidatos aún en el ejercicio de su carrera, incluso los que han permanecido activos después de su jubilación, pero el premio también puede otorgarse por la labor notable de toda una vida, independientemente de las fechas de actividad.

El Comité del Premio —que consta de cinco miembros, dos nombrados por el Director de la OPS y tres por el Consejo de Administración de la PAHEF— hace la recomendación definitiva de un candidato final al Consejo para su aprobación. El ganador recibe el premio de manos del presidente durante la reunión del Consejo Directivo de la OPS o de la Conferencia Sanitaria Panamericana y presenta una conferencia sobre un tema de su elección.

Las autoridades de salud de los Estados Miembros, el personal de la Organización y otras personas interesadas en el trabajo de la OPS y de la PAHEF quedan invitadas a presentar nominaciones de personas o grupos de personas con logros científicos o pedagógicos distinguidos en cualquier campo de la salud interamericana, según lo arriba especificado. Para que el Comité pueda considerar las nominaciones, deben incluir la información siguiente: nombre, dirección y posición actuales de la persona nominada; descripción detallada de los logros específicos que se juzguen merecedores del premio, con énfasis en su significado para la Región de las Américas; curriculum vitae completo (instrucción, puestos desempeñados, publicaciones, honores y menciones); y una nota breve en la que se resuman las razones por las que se considera que la persona nominada debe recibir el premio.

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