# APPLICATION OF ENVIRONMENTAL MANAGEMENT PRINCIPLES IN THE PROGRAM FOR ERADICATION OF *AEDES (STEGOMYIA) AEGYPTI* (LINNEUS, 1762) IN THE REPUBLIC OF CUBA, 1984[1]

*José A. Armada Gessa[2] and Rafael Figueredo González[3]*

## BACKGROUND

The Republic of Cuba includes the island of Cuba (the largest island in the West Indies Archipelago) and over 1,600 keys and islets. Cuba's mean average temperature is 77.7°F and its mean relative humidity is 79%. The rainy season runs from May through October with an average relative humidity of 82%, and the dry season runs from November through April with an average relative humidity of 77%.

In 1881 Cuba's Carlos Finlay formulated the brilliant theory that yellow fever was transmitted by the bite of the mosquito *Aedes aegypti*. However, between 1904 and 1954 no effective *Aedes aegypti* control programs were conducted in Cuba. As a result, high *A. aegypti* infestation rates, generally ranging from 11% to 26%, prevailed throughout the country.

Following the 1959 Revolution, a vertically organized *A. aegypti* control program was begun in four provinces where infestation indices ranging from 0.1% to 53.4% in infested localities were being reported. In 1967 this program was integrated into the General Health Services and started being conducted through the country's existing network of polyclinics. Nevertheless, the basic objective of *A. aegypti* eradication was not achieved.[4]

In 1977, dengue virus (serotype 1) was introduced into Eastern Cuba, leading to an epidemic that quickly spread to nearly every part of the country and produced at least 5,000,000 dengue cases.[5] From 1978 to May 1981, however, only sporadic cases were reported.

[1] This article will also be published in Spanish in the *Boletín de la Oficina Sanitaria Panamericana*, 1986.

[2] Entomologist, National *Aedes aegypti* Eradication Campaign, Ministry of Public Health, Havana, Cuba.
[3] Chief Medical Officer, National *Aedes aegypti* Eradication Campaign, Ministry of Public Health, Havana, Cuba.

[4] S. Martínez, J. Fernández, and C. Martínez; Erradicación del *Ae. aegypti* en Cuba, Congreso de Ingeniería Sanitaria, Panama, 1982.

[5] H. Terry, R. Figueredo, and J. A. Armada *(6)*.

In the first half of 1981, serologically distinct cases (caused by dengue-2 virus) began being diagnosed, and cases of dengue hemorrhagic fever were observed. In all, from May (when the epidemic began) until October (when it ended) a total of 344,203 cases and 158 deaths were reported, 101 (63.9%) of the dead being children less than 15 years of age. The epidemic peaked on 6 July 1981, when 11,721 cases were reported, and apparently ended on 10 October, the day the last case was reported.

## EMERGENCE OF THE NATIONAL *A. AEGYPTI* ERADICATION CAMPAIGN

When it became clear that this latter epidemic constituted a national emergency, Commander in Chief Fidel Castro, President of the Council of State and Council of Ministers, issued a directive on 9 June 1981 calling for termination of the epidemic and nationwide eradication of *Aedes aegypti*. To achieve these aims, a national *Aedes aegypti* eradication campaign was begun and immediate efforts were made to reduce prevailing *aegypti* infestations.

This national campaign was promptly provided with an organization, subject to strict discipline and control, that was appropriate for achieving nationwide *aegypti* eradication, and all personnel and material resources required were made available. Eradication activities were then initiated and were pursued concurrently throughout the country.

The campaign was divided into the following phases: (1) preparatory phase (10–31 July 1981); (2) attack phase (3 August–30 September 1981);[6] (3) consolidation phase (beginning 1 October 1981, one year); and (4) maintenance and surveillance phase (permanent, following *A. aegypti* eradication in each municipality). Overall supervision has been provided by a "National Directing Group" consisting of three medical officers (a chief, an assistant chief, and an epidemiologist), an entomologist, two supervisors, and clerical personnel. Under this group has been a "Provincial Directing Group" in each province consisting of a chief medical officer (in some provinces this post has been held by a veterinarian or a specialized health worker), an entomologist, several general supervisors, and clerical personnel. And last, work at the local level has been supervised by a "Municipal Directing Group" consisting of a municipal chief and one or more teams of supervisors directing several teams of inspectors (one inspector per 1,500 inhabitants) and controllers, as well as clerical personnel. Entomologists have been assigned to some of these municipal groups. In addition, the program has been supported by the provincial medical entomology laboratories, and by some 60 licensed entomologists who have provided technical analysis to support surveillance activities and to help pinpoint the causes of *aegypti* foci.

Overall, the personnel assigned to the campaign included 15 provincial directors, 60 entomologists, 27 general supervisors, 729 team leaders, 3,801 inspectors, and 1,947 controllers.

[6] The interim period (1–2 August 1981) provided time for personnel to get from the places where training seminars were held to their work areas.

## THE CAMPAIGN'S ACTIVITIES

The ecology of the *Aedes aegypti* mosquito is closely linked to man; indeed, anthropogenic factors are the main determinants of this domestic species' habitats. Consequently, the most effective way of fighting *aegypti* is to adopt rigorous environmental sanitation measures. In this regard, timely health education designed to enlist the community's active participation in the drive to reduce the number of foci is vitally important.

In our particular case, the existence of an ongoing hemorrhagic dengue outbreak dictated that quick and vigorous action should be taken to reduce the vector population, thereby breaking the epidemiologic chain of transmission. In this vein, the procedure of choice for dealing with an *aegypti*-transmitted viral disease outbreak fostered by a high density of the mosquito is aerial spraying designed to exterminate both imagoes and immature forms. If properly conceived and executed, such action provides the quickest way of reducing the general *aegypti* population. Another consideration weighed in deciding on appropriate measures included the fact that control measures with a nonselective impact (application of broad-spectrum insecticides, for example) often cause serious ecologic disruptions and may even provoke abnormal increases in vector or other harmful insect populations. For these reasons, and also because ultra-low-volume (ULV) insecticide applications are usually less generally toxic than treatments with conventional insecticide formulations, it was decided to rely on ULV applications. These included spatial treatments with ground-based ULV equipment (towed mechanical ULV generators), aerial ULV applications (from 6 June to 18 July, before the intensive attack phase began), and in-house cold ULV aerosol treatments applied with mechanical back-pack sprayers. The insecticide chosen for all of these applications was 95% malathion.

In addition, it is well-known that various interventions preventing, reducing, or eliminating suitable *aegypti* breeding-places and larval habitants provide a basis for effective vector control. Therefore, while the initial aggressive ULV adulticiding was still in progress, a simultaneous start was made on physical destruction, focal treatment with temephos (Abate), and perifocal treatment with fenthion (Baytex) of all actually or potentially positive breeding areas.

## THE ATTACK PHASE

During the intensive attack phase, which lasted from 3 August to 30 September 1981, the following actions were taken nationwide:

1) All premises were inspected every two months, and all foci were treated with 1% granular temephos (Abate) used as a larvicide at a dose of 1 ppm. Also, perifocal areas out to a distance of 200 meters from each focus were treated with a 2.5% suspension of fenthion (Baytex 40% wettable powder).

2) The interiors of all residences and other premises were treated every seven days with deodorized 95% malathion applied as a ULV aerosol from back-pack mist generators.

3) Exterior areas of cities and towns were sprayed with malathion

(95%, applied as a ULV aerosol) every seven days by towed ULV generators.

4) Decree-Law 27, which imposes fines on parties responsible for the existence of conditions propitious for the proliferation of *Aedes aegypti* (unsanitary conditions in houses and yards) was strictly enforced.

5) An intensive health education campaign was launched by means of posters, pamphlets, flyers, etc., and the mass media.

6) An extensive nationwide sanitation campaign was carried out, principally for the purpose of physically destroying actual and potential *A. aegypti* breeding-places with active public participation.

Equipment used during this attack phase included 207 towed ULV spray generators, 3,883 portable backpack ULV spray generators, 4,146 handheld sprayers, and other appropriate support equipment (including a total of 307 vehicles—motorcycles with side-cars, four wheel drive jeeps, tractors, trucks, and buses) depending on the sizes and needs of the particular provinces and municipalities involved.

At the end of the attack phase, the *A. aegypti* house infestation rate had been reduced considerably, by a factor of about 100 (Table 1). In addi-

**TABLE 1. *A. aegypti* house infestation rates observed before and during the eradication program (August 1981 through April 1984).**

| Date | | Phase of the eradication program | Infestation rate (% of houses found infested) |
|---|---|---|---|
| 5 August | 1981 | Around start of attack phase | 10.9[a] |
| 30 September | 1981 | End of attack phase | 0.11[a] |
| 12 December | 1981 | Consolidation phase, end of first cycle | 0.021 |
| 23 January | 1982 | " " " " second " | 0.012 |
| 20 March | 1982 | " " " " third " | 0.019 |
| 22 May | 1982 | " " " " fourth " | 0.020 |
| 13 August | 1982 | " " " " fifth " | 0.019 |
| 16 October | 1982 | " " " " sixth " | 0.011 |
| 11 December | 1982 | " " " " seventh " | 0.011 |
| 5 February | 1983 | " " " " eighth " | 0.014 |
| 2 March | 1983 | " " " " ninth " | 0.013 |
| 28 May | 1983 | " " " " tenth " | 0.007 |
| 30 July | 1983 | " " " " eleventh " | 0.012 |
| 24 September | 1983 | " " " " twelfth " | 0.009 |
| 26 November | 1983 | " " " " thirteenth " | 0.013 |
| 4 February | 1984 | " " " " fourteenth" | 0.009 |
| 16 April | 1984 | " " " " fifteenth " | 0.007 |

[a] Data do not accurately reflect the actual rates, which are presumed to have been much higher

tion, the number of dengue cases reported daily had dropped from 3,319 (reported on the day the attack phase began) to an average of only three to six per day (beginning 15 September).

## THE CONSOLIDATION AND MAINTENANCE PHASES[7]

The consolidation phase was initiated on 1 October 1981. During this phase, all the elements of the campaign were maintained. The intensity and scale of the attack operations were kept up so as to diminish the chances that physiologic resistance to the insecticides in use would emerge, and simultaneous nationwide coverage was continued. At the same time, sufficient flexibility was built into the program to permit adjustment of tactics or adoption of needed changes.

In addition, health education was provided through the mass media. This education, which stressed the importance of basic sanitation, has been a fundamental element responsible for the campaign's progress. It has also supported intensive sanitation efforts, employing some 1,200 trucks and 2,000 men, that have been conducted from time to time throughout the country.

As the foregoing suggests, this overall program has been given strong government support, reinforced by rigorous control and enforcement measures, and has enjoyed community understanding and participation—all of which have helped to ensure its success.

Another point that should be noted is that as the program has advanced, temporarily effective chemical spraying has given way to long-term environmental measures—partly to prevent potential development of mosquito resistance to the insecticides employed, and partly in recognition of the fact that frequent spraying is best used as a temporary stopgap. Specifically, beginning with the second cycle of the consolidation phase (which started on 23 January 1982), perifocal treatment with fenthion was suspended. Beginning with the third cycle (starting 20 March 1982), ULV spraying with 95% malathion was suspended. And beginning with the sixth cycle, perifocal application of temephos was suspended.

In addition, beginning with the second cycle all campaign inspectors began destroying useless containers with picks or piercing them in such a way that they would no longer hold water, thereby ensuring that they would not serve as breeding-places for *aegypti*. They also began brush-cleaning the insides of water storage containers.

Other measures designed to reduce *aegypti* breeding-places were as follows:

- A national ban was placed on use of water-bearing containers in cemeteries. Containers with sand or soil are permitted, provided that their bottoms are perforated so that no water can accumulate.
- Storage of water in containers without lids was forbidden throughout the country, and use of vehicle tires or tubes for animal feeding or drinking troughs was likewise prohibited.

[7] The consolidation phase pursued systematic eradication of *A. aegypti* through inspection and treatment cycles. This phase reached its scheduled end on 1 October 1982; but in order to provide better comparison with annual statistical data from other sources, the phase can be considered to have ended on 31 December 1982. The maintenance phase that followed the consolidation phase has involved elimination of *A. aegypti* breeding places that "survived" the preceding phases and permanent surveillance of the vector.

• The planting of bromeliads (e.g., *Bromelia pinguin*) as hedges to fence off properties was banned because of the plants' tendency to accumulate water in their leaf axils.

• The campaign concentrated on reduction of *aegypti* breeding-places as a means of eradicating foci and also encouraged adequate sanitary disposal of solid waste (including cans and other containers) in such a way as to avoid creating potential breeding-places.

• Biologic control was instituted in all major lakes and ponds by stocking them with larvivorous fish. The three indigenous species known to have the greatest predatory capacity were used for this purpose, namely *Precilia neticulata*, the guppy, which adapts readily to a wide variety of weather conditions and ecologic niches; *Gambusia punctata*; and *Gambusia puncticulata*. The particular larvivorous species used depended upon the ecologic characteristics of the lake or pond involved.

• An effort was made to persuade the public that these fish offered a safe and effective means of vector control, and this secured community participation in the biologic control operation.

Another key program action has been the creation of "vector controllers." These controllers, who have made a major contribution, are women organized into teams or "brigades." Their work, which is appropriately supervised and regulated, consists of activities in the areas of health education, entomologic surveillance, and assessment of the technical quality of the visiting health worker teams' performance. In effect, they act as a corps of inspectors, making weekly visits to places considered potentially dangerous breeding areas—such as spillways, junkyards, cemeteries, and so forth. These vector controllers are authorized to impose fines under Decree-Law 27 for sanitary violations.

**TABLE 2. *A. aegypti* infestations indicated nationwide by weekly inspections of larvitraps placed for surveillance of the mosquito.[a]**

| Cycle No. | No. of larvitraps installed | Traps positive for *A. aegypti* | | No. of *A. aegypti* specimens captured and examined |
|---|---|---|---|---|
| | | No. | % | |
| 2 | 5,065 | 2 | 0.04 | 8,062 |
| 3 | 6,434 | 7 | 0.11 | 23,867 |
| 4 | 9,946 | 5 | 0.05 | 33,922 |
| 5 | 9,393 | 14 | 0.15 | 10,257 |
| 6 | 11,504 | 16 | 0.14 | 51,975 |
| 7 | 12,585 | 15 | 0.12 | 66,347 |
| 8 | 13,383 | 15 | 0.11 | 54,060 |
| 9 | 13,893 | 12 | 0.09 | 89,525 |
| 10 | 14,585 | 6 | 0.04 | 73,261 |
| 11 | 14,068 | 13 | 0.09 | 74,880 |
| 12 | 14,536 | 20 | 0.14 | 69,590 |
| 13 | 14,755 | 11 | 0.07 | 91,343 |
| 14 | 14,929 | 11 | 0.07 | 82,062 |
| 15 | 15,401 | 8 | 0.05 | 84,676 |

[a] Each trap is made by taking a quarter of a car tire and situating it 50 cm above the ground, following the technical recommendations for use of the classic ovitrap. The interior of the trap is brushed clean before installation and its water content is noted every seven days at the time when larvae and pupae are collected for classification and new water is placed in the trap.

It should also be noted that the program employs all the basic elements of entomologic surveillance, as follows:

- Ovitraps and larvitraps that consist of a 45 cm section of tire containing water are placed at residences and other premises throughout the country, according to specific ecologic requirements, and are inspected at precise seven-day intervals. The results of this larvitrap surveillance are shown in Table 2.
- Adult vectors are captured by controllers inside houses in the course of their regular visits.
- Fixed adult-capture stations operating at regular intervals and with regular hours have been established.
- Collections are made of all aquatic larvae detected in breeding-places during inspections of residences and other premises (including empty lots).
- All material collected is sent to the Provincial Medical Entomology Laboratory for taxonomic classification.
- Areas of entomologic risk are determined—these being areas that have a high potential for harboring and generating *aegypti* vectors.

Overall responsibility for maintaining the technical quality of the surveillance system, providing advice about the vector, making taxonomic determinations, and performing entomologic analyses of detected *aegypti* foci rests with 60 licensed entomologists based at medical entomology laboratories. One of these laboratories is located in each of Cuba's 14 provinces and in the Special Municipality of the Isle of Youth.

## Summary

The dengue epidemic that struck Cuba in 1981 caused a total of 344,203 reported cases and 158 deaths. The Cuban Government's response to this emergency was to launch a major eradication campaign against the vector mosquito *Aedes aegypti*—by spraying to kill adults in the first months and by adoption of various longer-term measures designed to progressively reduce and eliminate *aegypti* populations.

These latter measures included focal and perifocal treatment of breeding areas, physical destruction of actual or potential breeding-places, modification of drinking-water tanks and other containers so as to render them unsuitable for *aegypti* proliferation, stocking of lakes and ponds with larvivorous fish, an intensive health education campaign, pursuit of ongoing *aegypti* surveillance activities, and enforcement of sanitary regulations prohibiting the maintenance of conditions suitable for *aegypti* breeding. This major effort reduced the *aegypti* house infestation index from 11% or more in early August 1981 to 0.1% in January 1982, and has succeeded in keeping it down to around that level or below since then. The campaign thus provides a good current example of how *aegypti* can be successfully controlled given sufficient funds, personnel, equipment, government backing, and broad public support.

## Bibliography

1 Armada, J. A., and J. A. Trigo. Técnicos de lucha anti-*aegypti*. Ministerio de Salud Pública, Havana, 1981.

2 Armada, J. A. Acerca de la lucha antivectorial. *Revista Temas de los Laboratorios de Higiene, Epidemiología y Microbiología* 1(1), 1974. Instituto Nacional de Higiene, Epidemiología y Microbiología, Ministerio de Salud Pública, Havana.

3 Ministerio de Salud Pública. Proyecto de Código Sanitario de la República de Cuba, Havana, 1978.

4 Ministerio de Salud Pública. Informes finales: Ciclos Campaña Nacional de Erradicación del *Aedes aegypti*. Havana, 1982–1984.

5 Odum, E. P. *Ecology*. 1966.

6 Terry, H., R. Figueredo, and J. A. Armada. Informe preliminar de la Campaña Nacional de Erradicación del *Aedes (s) aegypti*, Cuba 1982. Paper presented at the Meeting of the Technical Group on *Aedes aegypti*, Dengue, and Yellow Fever held at Mexico City, Mexico, in 1982.

7 Tonn, R. Asesoría a la campaña anti-*Aedes aegypti* en Cuba. Informe OPS, Cuba 5100, 1981.

8 Tonn, R., R. Figueredo, and L. J. Uribe. *Aedes aegypti*, yellow fever, and dengue in the Americas. *Mosquito News*, Vol. 42, No. 4, December 1982.

9 World Health Organization. *Vector Ecology*. WHO Technical Report Series, No. 501. Geneva, 1972.

10 World Health Organization. *Engineering Aspects of Vector Control Operations*. WHO Technical Report Series, No. 603. Geneva, 1977.

11 World Health Organization. *Environmental Management for Vector Control*. WHO Technical Report Series, No. 649. Geneva, 1980.

12 World Health Organization. *Resistance of Vectors of Disease to Pesticides*. WHO Technical Report Series, No. 655. Geneva, 1980.

13 World Health Organization. *Environmental Management for Vector Control*. WHO Technical Report Series, No. 649. Geneva, 1980