strictions on generalization and demands consideration of costs, benefits and effects. It happens exactly that these considerations represent the major principles of the integrated control and hence the present trend will lead towards the gradual adoption and application of this approach. To speed up progress and to ensure that this transformation will take place correctly and in an orderly manner, it is essential that the process is well studied and planned, taking into consideration the present and future needs and resources.

AEDES AEGYPTI, YELLOW FEVER AND DENGUE IN THE AMERICAS[1]

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ABSTRACT. Many *Aedes aegypti* eradication and control campaigns are faced with administrative, financial, and technical constraints. At the same time *Ae. aegypti* appears to be extending its geographical distribution and utilizing an increasing number of different larval habitats. Countries such as Brazil, Bolivia and Paraguay have had *Ae. aegypti* reinfestations. Jungle yellow fever has spread into areas closely adjoining urbanizations infested with *Ae. aegypti* and the potential for urban yellow fever remains great. Since 1965 jungle yellow fever has been reported in 12 countries with 228 cases occurring in 1981. All 4 serotypes of dengue occur in the Americas with a major pandemic of dengue serotype 1 beginning in 1977. In 1981 dengue serotype 4 was identified in the Caribbean and it has spread to at least 13 countries. Dengue haemorrhagic fever appeared in Cuba in 1981 with 344,203 cases and 158 deaths. The etiological agent has been identified as dengue serotype 2. The control measures are described.

INTRODUCTION

The success of *Aedes aegypti* control measures used by Gorgas and his associates in 1901 in Cuba is well known. Similarly the measures begun in Panama in 1904 proved equally spectacular. As a result the Rockefeller Foundation in 1915 became committed to eradicate yellow fever from the World.

As the cooperative Brazilian-Rockefeller Foundation Program advanced, Soper and others began to believe that eradication of *Ae. aegypti* was technically feasible. Jungle yellow fever occurring without involvement of *Ae. aegypti* was a set-back in the eradication of yellow fever, nevertheless the countries of the Americas became committed to eliminate *Ae. aegypti*. In 1947 the Pan American Health Organization (PAHO) assumed the responsibility for continental eradication. This responsibility has since been enhanced by a number of resolutions passed by governing councils.

Yet *Ae. aegypti* has not been eliminated and appears to be as successful as ever against control measures. This failure has placed a severe financial burden upon a number of countries. All 4 dengue serotypes are found in the Americas and the first epidemic of dengue haemorrhagic fever occurred in 1981. Equally alarming has been the appearance of

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jungle yellow fever at the doorsteps of the urban vector in Colombia, Bolivia and Trinidad.

THE *Aedes aegypti* SITUATION. It has been 81 years since the war against *Ae. aegypti* in the Americas began. Bolivia in 1943 was the first country to eradicate *Ae. aegypti*. With the introduction of DDT as a residual insecticide, a number of campaigns made substantial headway towards eliminating the mosquito. The Operational Manual of PAHO in 1956 proclaimed that with DDT, *Ae. aegypti* campaigns were sure to succeed. Unfortunately resistance to DDT appeared and the mosquito began to win the battle.

Today, *Ae. aegypti* is still winning over the efforts of man despite new control equipment and insecticides as well as millions of dollars being spent annually against it. *Aedes aegypti* has probably become more adaptive to the careless ways of man with beer cans, soft drink bottles, discarded tires, and other containers serving as suitable larval habitats. For this reason, as well as financial, administration and other constraints, some believe that the campaigns of Gorgas, Soper and others might not be effective today.

Recently in Colombia, *Ae. aegypti* was found breeding at over 2200 meters as well as in rural areas not served by roads. More and more countries are reporting the occasional breeding in natural containers such as tree and rock holes. In a survey in Anguilla, *Ae. aegypti* was found breeding in rock holes a short distance from the coast with 5 to 58 percent of the holes surveyed in 8 localities positive.

Introductions of *Ae. aegypti* are continually occurring in a number of countries. Almost every month one or more boats entering ports in Panama are found infested with *Ae. aegypti* and practically every year there is a reinvasion by ground or sea of Ecuador. Islands of the Caribbean have reported similar invasions by sea. This has resulted in the need for many countries to maintain an active surveillance program.

Unfortunately surveillance programs are frequently not effective and *Ae. aegypti* becomes established in the country. Reinfestations have occurred in Brazil in 1976, Bolivia in 1980, and in Paraguay in 1981.

Aedes aegypti appeared in Salvador, Brazil in 1976 and began to spread to the north and south. In spite of an active campaign to eliminate the mosquito, it still is found in at least 20 localities. The present cost per year of the program, exclusive of staff, is 200 million cruzeiros. Brazil has found ships entering Brazilian ports from Nigeria (1980–81), the Guianas (1980), and the United States (1981) with *Ae. aegypti* breeding.

During a training exercise on 7 February 1980 near the airport at Santa Cruz, Bolivia, breeding of *Ae. aegypti* was found. Surveys soon showed extensive breeding throughout the city at Cotoca and kilometer 15. A campaign using source reduction, space spraying and larvicides was mounted immediately. In spite of the campaign, by 1981 its distribution had increased along the Santa Cruz-Cochabamba highway and it was found in Montero and Warnes. The Government spent US $392,000 in 1981 for control and it is estimated that well over a million dollars is needed to conduct a good eradication campaign. Jungle yellow fever is present near Santa Cruz and an extensive vaccination program of the city and of migrant workers is in progress.

In 1981 *Ae. aegypti* was discovered in the seaport and airport of Asunción, Paraguay. Surveys have shown infestation from the Brazilian to the Argentinian borders. The infestation is extensive and there is danger of Argentina and Uruguay becoming reinfested.

The situation of *Ae. aegypti* eradication programs has deteriorated in the last decade. Only 8 countries continue to be free of *Ae. aegypti* and maintain surveillance activities. Other countries either have limited or extensive infestations and in many cases there has been an extension of infestation. Programs will have to be rejuvenated in many countries to protect against epidemics of dengue and possible urban yellow fever.

YELLOW FEVER. Jungle yellow fever

as a zoonosis was demonstrated in the Americas in 1933. This finding showed that eradication of the disease through control of *Aedes aegypti* was not feasible. However, effective control in urban areas could lessen the threat of epidemics in populated areas. In 1948 an epizootic of jungle yellow fever invaded Panama and for almost a decade slowly moved northward in Middle America. Since 1957 jungle yellow fever has been absent from Central America but occasional activity has been reported in Panama.

Many South American countries have reported cases of jungle yellow fever since 1933. The presence of *Ae. aegypti* in urbanizations adjoining areas with jungle yellow fever has caused concern to health officials. Colombia for the past several years has had a number of epidemics near *Ae. aegypti* infested cities.

Twelve countries have reported a total of 2,146 jungle yellow fever cases since 1965. It is accepted that this is an underestimation of the true picture of yellow fever. In fact there exists an urgent need to define the vectors, reservoirs, and epidemiology of jungle yellow fever. Several aspects needing study are: 1) species of *Haemagogus* and *Sabethes*, the sylvan vectors, are poorly known and other mosquito genera may be involved in transmission; 2) species of *Haemagogus* and *Ae. aegypti* coexist in the same larval habitats in some semiurban areas and *Haemagogus* has been captured in urban areas; 3) reports exist of the occurrence of jungle yellow fever where monkeys and known vectors were not found; 4) cases are found in isolated areas where jungle yellow fever has not been previously found and 5) extensive human migrations and developmental projects make immunization programs expensive and only partially effective.

Table 1 gives recent information on jungle yellow fever in the Americas. Each year there are new areas of activity. An epidemic in 1979 in Trinidad produced 18 diagnosed cases with 7 deaths. This epidemic began as an epizootic in Red Howler monkeys (*Alouatta sericulus*) in the south of the island and moved northward. The most recent large epidemic began on 21 October 1981 in Sara, Bolivia. It moved into Andres Ibañez, a forest and agricultural area near Santa Cruz in 1982, causing to date 70 diagnosed cases with a case fatality rate of 47.6% in the province. As of 6 April 1982 a total of 83 cases have been reported in Bolivia for the year.

DENGUE. Historically, dengue has been known as a clinical entity in the Americas for about 200 years. In 1952 dengue serotype 2 was isolated in Trinidad and in 1963 dengue serotype 3 was isolated in Puerto Rico. Until 1977 these were the only serotypes known to the Americas. However, on 26 February 1977 cases of dengue serotype 1 appeared in Jamaica. This serotype caused a major epidemic spreading throughout the Caribbean, Suriname, French Guiana, Guyana, Venezuela, Colombia and the Central American countries of Honduras, El Salvador, Belize and Guatemala. In Mexico it entered at Topachula near the west coast and followed the Pan American highway northward with cases occurring in Texas in 1980. During this epidemic, cases with clinical manifestations similar to dengue haemorrhagic fever and dengue shock syndrome were reported from Jamaica, Haiti, Honduras, Puerto Rico and Colombia. Dengue serotype 1 activity is still reported in the Americas.

In April 1981 the Centers for Disease

Table 1. Reported cases of jungle yellow fever in the Americas, 1977–81.

Country	Number of cases per year					
	1977	1978	1979	1980	1981	Total
Bolivia	2	11	10	46+	92	161
Brazil	9	27	12	27	14	89
Colombia	9	105	51	11+	6	182
Ecuador	0	1	14	2+	0	17
Peru	82	93	97	30+	99	401
Trinidad	0	0	18	0	0	18
Venezuela	0	3	3	4+	0	10
Total	102	240	205	120	211	878

Control reported dengue serotype 4 infections from two tourists returning from the Caribbean Lesser Antilles. This serotype undoubtedly had been in the Caribbean for some time before this report. An epidemic was reported in Dominica in May and it has been suggested that it was introduced during a carnival on 2–3 March and dengue activity appeared in Roseau by 16 March 1981.

The dengue serotype 4 has not spread as rapidly as serotype 1 and has produced a mild disease of short duration characterized by high fever, gastroenteritis and some rash. No deaths have been reported. Although movement has been slow, a number of countries have reported serological evidence of dengue serotype 4 activity. These include Dominica, Grenada, Trinidad, Jamaica, Belize, St. Thomas, St. Bertholomew, Guadaloupe, Curacao, Haiti, British Virgin Islands, St. Martin and Puerto Rico. Table 2 provides a summary of dengue epidemiological data for the past several years. Because of the nature of the disease and the fact that it is not an official reportable disease, these data are underestimates.

Table 2. Reported cases of dengue in the Americas, 1978–81.

Year	No. countries	No. cases
1977	19	503,107
1978	24	125,346
1979	17	41,810
1980	13	32,600
1981	19	354,490

DENGUE HAEMORRHAGIC FEVER IN CUBA. The epidemic of dengue serotype 1 began in 1977 in eastern Cuba and rapidly spread throughout the country. This epidemic produced 553,132 notified cases and it was estimated that for every clinical cases there were 10 subclinical or inapparent ones. In June 1981 cases of dengue began to occur again in Cuba. This time, there was haemorrhagic fever and shock syndrome which satisfied the WHO criteria for dengue haemorrhagic fever. The etiological agent was identified as dengue serotype 2 virus. A total of 344,204 cases were recorded with 158 deaths of which 101 were in children under 15 years. The epidemic peaked on 6 July with 11,721 cases and the last case was reported on 10 October with the epidemic declared over on 19 November.

Aerial ULV application of malathion began on 6 June and ended on 18 July. At the same time ground forces were mobilized for space spraying, source reduction and larviciding. During the same time a plan of action was produced calling for a 4 step eradication program. The first step or preparatory phase ran from 10 to 31 July 1981, the second step or intensive attack phase from 3 August to 30 September and a third step or consolidation phase from 1 October until eradication was complete. The last step or surveillance would be permanent. On 26 July the Commander in Chief, Fidel Castro announced the beginning of the campaign to eliminate dengue and to eradicate *Ae. aegypti* from Cuba.

PREPARATORY PHASE. The estimated average *Ae. aegypti* premises index was 35 before any emergency measures were put into effect. Upon studying the problem and taking into consideration constraints that were evident in many countries during the previous dengue serotype 1 epidemic such as lack of discipline, dedication, motivation, and the vector's possible development of resistance to insecticides, it was decided to mount an intensive attack against the vector. The plan called for formation of control activities in all 169 municipalities. Dengue was declared a national emergency allowing Civil Defense to mobilize their resources for the intensive attack phase. Although the program followed the suggestions of Soper in being a quasimilitary operation and to cover the entire country simultaneously, a flexible program was adopted that could easily be changed as needed.

INTENSIVE ATTACK PHASE. On 3 August the intensive attack phase began. From 13,000 to 15,000 members of Civil De-

fense, Vector Control, and the *Aedes aegypti* Campaign as well as other staff from industrial and governmental agencies were involved. The equipment utilized for the attack included 215 ground vehicle-mounted ULV fog generators, 3,961 portable mistblowers, 4,407 hand compression spray pumps, and 307 vehicles.

The following measures were taken:

1. 100 percent coverage with temephos 1% sand granules as a focal larvicide at doses of 1 ppm and a perifocal treatment using fenthion 40% wdp at a dose of 2.5%.
2. 100 percent coverage of the interior of the premises using motorized backpack mistblowers with 95% deodorized malathion at 7 day cycles.
3. Street spraying with ULV or thermal fog generators in villages and cities using malathion at 7 to 10 day cycles.
4. Activating Law 27 on Sanitation which authorizes vector and *Ae. aegypti* Campaign staff to issue legal summons to those not having eliminated breeding sites.
5. Initiating an intensive health education campaign and special clean-up days.
6. Establishing special teams of evaluators to inspect premises, treat missed containers with temephos and provide health education.

The day the intensive attack began, 3,319 cases were reported, while after 15 September an average of only 3 to 6 cases were reported per day. By the end of August, the provincial averages for the *Ae. aegypti* premises index ranged between 0.6 and 0.0 for a national average of 0.2. By the end of this phase the national average was 0.09.

The consumption of insecticide for the campaign was 120.8 tons of temephos 1% sand granules, 96.6 tons of fenthion 40% wdp, 563.2 tons of malathion 95% ULV for interior of premises and 176.4 tons of malathion 95% ULV for street space spraying.

CONSOLIDATION PHASE. This phase began on 1 October 1981 when all activities of eradication were transferred to the National *Aedes aegypti* Campaign. At that time staff was reduced to 6,676 persons in the field and a national headquarters staff of 13. Treatment cycles and evaluations were similar to those of the attack phase, except a system of 5,065 ovitraps were used from the second cycle on. An intensive attack was planned for the beginning of the rainy season in May–June 1982 to safeguard against a potential increase in breeding habitats.

The results of the first cycle showed 509 houses of 2,339,652 positive for *Ae. aegypti* for a premises index of 0.021%. A total of 89.8 tons of temephos 1% sand granules, 29.7 tons of malathion 95% ULV and 89.1 tons of fenthion 40% wdp was used.

There was a slight reduction in the number of houses visited in the second cycle. Of 2,307,454 houses visited only 298 or 0.012% were positive. A total of 90.7 tons of temephos 1% sand granules and 29.2 tons of malathion 95% ULV was used. The use of fenthion as a perifocal residual was discontinued. Only 0.04% of the ovitraps were positive.

The consolidation phase is expected to last one year. To reduce the possibility of organophosphate resistance during the phase, inspectors will use sharp picks to puncture metal containers, campaigns will be mounted to continue to motivate communities in source reduction and there will be a strict enforcement of Law 27.

When a breeding source is discovered, an intensive attack against *Ae. aegypti* is undertaken in a 300 to 500 meter radius of the source.

This program represents one of the most intensive attacks ever waged against a vector. The strength of the approach was a result of the Government to make the program both a national and an individual priority. Eradication is not complete but an exceedingly low level of *Ae. aegypti* was achieved rapidly. The campaign has illustrated that at least the battles, if not the war, can be won against *Ae. aegypti*.