the end of the dry season (May or June) this treatment would be even more attractive with respect to costs. Some observations will be made on the feasibility of this plan during 1964.

The data and conclusions from this study are applicable only to the East Coast of Florida, where normal tides do not flood salt marshes during the summer. Limited studies with impounding on the Gulf Coast of the State, where tides frequently flood salt marshes between April and September, have not been encouraging. Additional studies will be necessary in order to assess the value of impounding on the West Coast of Florida.

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ERADICATION OF *AEDES AEGYPTI* IN LATIN AMERICA

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In 1947 the Pan American Sanitary Bureau was charged with the responsibility for the coordination of the *Aedes aegypti* Eradication Campaign in the Americas. As of December 1963 the eradication of *Aedes aegypti* from 17 countries and territories in the Americas had been certified, with Argentina apparently about to be added to the list as the 18th country.

But this was an eradication campaign, and eradicators can never rest on the laurels of what they have accomplished as long as the task they have undertaken is incomplete. Instead, attention and effort must be focused on what remains to be done. In Figure 1 it may be seen that success has been attained in Mexico, all of Central America, and all of South America except what may be called its Caribbean Coast. There is trouble in the Caribbean, and the situation there is not so good as it was five years ago. Several territories from which *aegypti* had been eradicated have been reinfested. The earlier *aegypti* appeared to be DDT-susceptible; the reinvaders are definitely DDT-resistant, and often dieldrin-resistant, too.

The problem is complex in the Caribbean not only because of biological factors, but also because of economic and administrative ones.

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At the end of 1963, *aegypti* eradication programs were active in Barbados, Curaçao and Surinam, but in all these territories resistance to DDT and dieldrin was hindering operations. A program was prepared for British Guiana and is under discussion. Elsewhere the campaign is at a standstill, programs in the British Virgin Islands and Antigua having been suspended. In spite of the occurrence of a dengue outbreak in Jamaica, the program has not been reactivated in that country.

Bermuda, which is included in the Caribbean area only for convenience, has reported no *aegypti* for many years. A special verification was made, without finding any *aegypti,* with the result that before long it may be possible for the Directing Council of PAHO to certify the eradication of *Aedes aegypti* from that island.

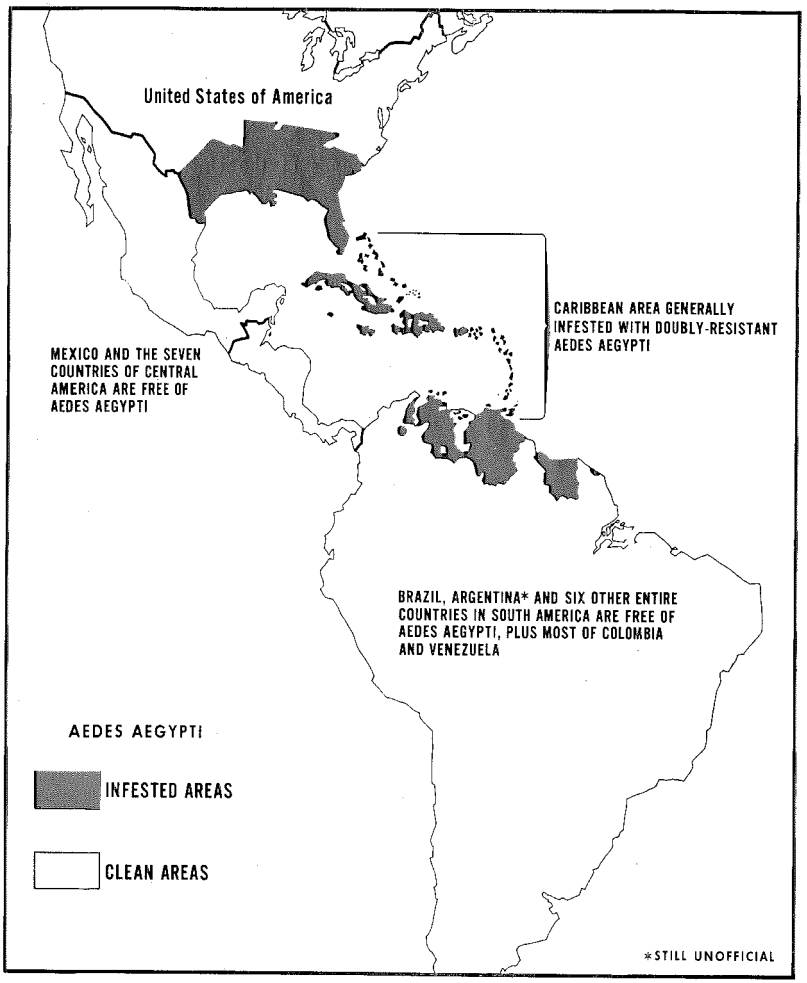

FIG. 1.—General status of the *Aedes aegypti* eradication campaign in the Americas as of December 1963.

In 1962 PAHO began a new phase of its activities in the Caribbean, with the assignment of a professional entomologist to duty at the PAHO Aedes Aegypti Testing Laboratory in Kingston, Jamaica. This project was established with the cooperation of the Ministry of Health of Jamaica and the University of the West Indies, at Mona (near Kingston), Jamaica.

The Aedes Aegypti Testing Laboratory has three main objectives at present:

1. To determine the susceptibility of *Aedes aegypti* from the countries and territories of the Caribbean to DDT, dieldrin and candidate insecticides to replace DDT.

2. To evaluate various insecticides for use in *aegypti* eradication operations in the Caribbean in those countries in which the species is resistant to both DDT and dieldrin.

3. To study the ecology of *aegypti* in the field in a search for vulnerable points at which the species might most easily be attacked. The major aspect of this objective is to identify the primary breeding places of *aegypti*.

SURVEY OF THE SUSCEPTIBILITY OF *Aedes aegypti* IN THE CARIBBEAN. In the majority of the Caribbean countries and territories the *aegypti* eradication operations have been based on the use of DDT applied by the "perifocal" method, i.e. the spraying of DDT in a water-wettable suspension, in and around all potential *aegypti*-breeding places, plus any adjacent wall surfaces within a radius of three feet.

Beginning in 1954 Trinidad government workers observed low mortality of *aegypti* larvae in containers thus treated. This led to the demonstration of DDT-resistance of *aegypti* in Trinidad. Some years later *aegypti* from Isla Verde, Puerto Rico, were shown by Fox (1960) to be resistant to dieldrin in addition to DDT.

The present report discusses the results of studies done by the PAHO *aegypti* eradication personnel in the Caribbean to ascertain the susceptibility of *aegypti* from all the countries and territories in the Caribbean to DDT and dieldrin, and to some other candidate insecticides as well. Routine tests for *aegypti* susceptibility in the larval stage were begun in 1959 but were not put on a systematic basis until August 1962 when PAHO assigned the full-time professional entomologist to the program.

Two procedures were used in the study:

1. Tests were done in the field with wild larvae collected in different parts of each locality from assorted artificial containers. The larvae thus collected were pooled before being tested. The largest available larvae were used, and an estimate made of their stage of development.

2. Laboratory tests were done on colonized *aegypti* in the field laboratory which had been constructed by the Malaria Service of the Government of Jamaica on the grounds of the University of the West Indies. By this means it was possible to obtain large numbers of larvae of the same generation, age, and state of nutrition. The larvae used in the tests were, preferably, early fourth stage.

The susceptibility tests used the standard WHO technique for determining the susceptibility of larval mosquitoes to insecticides. In so far as possible a sufficient number of concentrations was used to obtain a range of mortality from below 50 percent to 100 percent. Being eradicators, the PAHO personnel are primarily interested in the LC100 because it indicates the level of resistance, rather than in the LC50 which deals with the most susceptible part of a population that may be heterogeneous. When the number of mosquito larvae was inadequate for full testing, LC50 and LC 100 values could only be approximated. Whenever possible, tests done in the field were repeated on colonized individuals of a subsequent generation.

Up to January 1964 tests had been done in 64 localities in 16 countries or territories, comprising reasonably complete coverage of the entire Caribbean area, with the result that there are no known populations of *aegypti* that are considered to be susceptible to either DDT or dieldrin at the present.

Experience has taught PAHO personnel that in *aegypti* eradication operations it

TABLE 1.—Results of representative susceptibility tests, with six insecticides, of larvae of *Aedes aegypti* from six countries and territories in the Caribbean area.

Country Locality	Date collected	Gen: P or F	Malathion LC 50	Malathion LC 100	Malathion Inter-pret.	Fenthion LC 50	Fenthion LC 100	Fenthion Inter-pret.	Diazinon LC 50	Diazinon LC 100	Diazinon Inter-pret.	Deutero-DDT LC 50	Deutero-DDT LC 100	Deutero-DDT Inter-pret.	Sumithion LC 50	Sumithion LC 100	Sumithion Inter-pret.	Dimethrin LC 50	Dimethrin LC 100	Dimethrin Inter-pret.
Curaçao																				
Willemstad	Dec. 62	F_1	0.17	1.0	R?	..	..	..	..	..	..	0.2	>1.0	?	..	..	..	..	..	..
Dominican Republic																				
Santo Domingo	Sept. 62	P	0.06	0.5	S	0.004	0.02	S	0.07	..	S	..	..	..	..	..	..	..	..	..
Azua	Sept. 62	F_1	0.1	0.5	S	0.002	0.02	S	0.06	0.5	S	..	..	..	..	..	..	..	..	..
Hato Mayor	Sept. 62	P	..	..	..	0.002	0.02	S	..	..	..	..	..	..	..	..	..	..	..	..
" "	Sept. 62	F_1	..	..	..	..	..	..	0.3	2.5	?	..	..	..	..	..	..	..	..	..
Moca	Sept. 62	F_1	..	..	..	0.005	0.02	S	0.08	0.5	S	..	..	..	..	..	..	..	..	..
Puerto Plata	Oct. 62	F_1	..	..	..	0.008	0.1	S	0.2	2.5	?	..	..	..	..	..	..	..	..	..
Santiago	Aug. 62	F_1	0.03	0.1	S	0.004	0.02	S	0.07	0.5	S	..	..	..	..	..	..	..	..	..
Vega, La	Sept. 62	F_1	0.12	0.5	S	0.08	0.5	?	..	..	..	..	..	..	..	..	..	..	..	..
Grenadines																				
Carriacou	Feb. 62	F_1	0.08	0.5	S	0.06	0.1	S	0.16	1.0	?	..	..	..	..	..	..	..	..	..
"	Feb. 62	F_2	0.25	1.0	?	..	..	..	..	..	..	0.45	>1.5	?	..	..	..	..	..	..
Jamaica																				
Bellas Gate	Oct. 62	F_2	..	..	..	0.008	0.04	S	..	..	..	..	..	..	0.01	0.04	S	0.65	2.0	S
Duncas	Nov. 62	F_1	0.14	0.5	S	..	..	..	0.2	1.0	R?	0.14	0.5	?	0.024	0.04	S	..	..	..
"	Nov. 62	F_1	..	..	..	..	..	..	..	..	..	0.5	>1.0	?	..	..	..	..	..	..
Lionel Town	Oct. 62	F_2	0.15	0.5	S	0.07	0.1	S	0.25	1.0	R?	0.4	>0.5	?	0.03	0.05	S	1.1	4.0	S
" "	Oct. 62	F_2	0.13	0.5	S	..	0.02	S	0.17	1.0	R?	0.08	0.2	?	0.024	0.1	S	..	..	..
St. Vincent	Nov. 62	F_1	0.16	0.5	S	0.006	0.02	S	0.16	0.5	S	0.1	>0.5	?	0.015	0.05	S	..	..	..
" "	Nov. 62	F_2	0.11	0.2	S	..	..	..	0.14	0.5	S	..	..	..	..	..	..	0.53	1.0	S
St. Lucia																				
Babonneau	June 62	P	0.19	1.0	R?	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Surinam																				
Several localities	Mar. 63	P	0.4	1.2	R?	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..

pays to use conservative criteria for DDT- and dieldrin-resistance of *Aedes aegypti*. We follow the studies of Parker (1957) on fully susceptible *aegypti*, and accept the concentration of 0.2 p.p.m. as the critical one for the LC100 with both DDT and dieldrin. If more than three percent of the larvae survive at that concentration in the WHO susceptibility test we consider such survival to be due to physiological resistance.

In one case, at Road Town in the British Virgin Islands, tests were done in 1959 previous to the start of anti-*aegypti* operations and again three years later. An increase in resistance to both DDT and dieldrin was found.

The results of field inquiries and laboratory tests lead us to conclude that the resistance of *aegypti* to chlorinated insecticides, both DDT and dieldrins is widespread in the Caribbean and that it is not always the result of anti-*aegypti* operations. The use of insecticides for domestic and agricultural purposes is believed to be one of the causes of this resistance.

Because of easy communication between the various islands of the Caribbean, often by small sailing vessels with potential breeding places for *aegypti* on board, not to mention harborage for *aegypti* adults, the dissemination of the species from one island to another is greatly facilitated.

The results of representative susceptibility tests of *aegypti* larvae from six countries and territories in the Caribbean to six candidate insecticides as possible replacements for DDT and dieldrin are presented in Table 1.

The technique used to test these insecticides was essentially that of the WHO tests for susceptibility. These studies are still in the exploratory stage, and the interpretations of susceptibility or resistance are still provisional. Much more testing of this sort needs to be done, and the crucial point is the rapidity with which populations of *aegypti* develop resistance to any insecticide that is used for their eradication.

THE EVALUATION OF CANDIDATE INSECTICIDES FOR USE IN *Aedes aegypti* ERADICATION OPERATIONS IN THE CARIBBEAN. For the evaluation of the various candidate insecticides as *aegypti* larvicides Zwick (1964) has selected seven different types of artificial containers as a "standard set." These are the containers of fresh water—including drinking water—in and around human habitations in which *aegypti* breeds most commonly in the Caribbean area. The standard set of containers comprises: The discarded rubber tire, the black iron drum, the wooden barrel, the plain tin can, the painted tin can, the clay pot, and the glass jar. One set of seven containers was used for each of the insecticides tested. Zwick (1964) has reported the results of tests on malathion, fenthion and carbaryl compared with DDT and dieldrin. The bio-assay was done using 25 larvae for each three-fold dilution of the sample of water removed from the test container, following essentially the WHO technique for susceptibility of mosquito larvae to insecticide.

Water was removed from each of the containers at 1, 2, 4, 6, 8, 11, and 13 weeks after the containers were charged, and bioassayed with a laboratory colony of *aegypti* resistant to both DDT and dieldrin.

The results of these tests, done in a single container and without any retests to date, were the following.

With DDT, as expected, the results were very poor in the rubber tire, the black iron drum, the wooden barrel, and the painted tin can; they were better, but by no means good, in the glass jar and clay pot.

With dieldrin the results were somewhat better than those with DDT but still not satisfactory. Except in the glass jar, 100 percent kill was not obtained in any test.

With malathion the results were not all that might be expected. Kills were high initially but in almost all cases they dropped rapidly to zero.

With fenthion, tested as Baytex (R), the results were excellent in five of the seven containers. In most of the containers the 1/27 dilution gave high kills for most of the 13 weeks, but in the clay pot

the results were poor, and in the rubber tire they were very poor.

The results with carbaryl were unsatisfactory.

Abedi and Aarons (1964) have reported on a second series of similar tests involving four more insecticides—dimethrin, paris green, trichlorfon, and naled—with the following results:

Dimethrin is an interesting new substance, a synthetic analogue of pyrethrin considered to be non-toxic for mammals. It can be ingested in huge doses without any symptoms. It may be noted that in all containers it shows some effect through the whole period of twelve weeks, best in glass and perhaps poorest in the wooden barrel.

PARIS GREEN. Note the excellent results in the rubber tire and the complete absence of effect in the black iron drum, presumably because the rust which forms rapidly "neutralizes" the paris green. The results in the other containers were variable.

TRICHLORFON is an organo-phosphorus insecticide. It is more active than malathion, but it is also more toxic to mammals. Like malathion, it gave 100 percent kills for a few weeks and then completely lost its effect. Except in the wooden barrel it had no effect after four weeks; in the clay pot it had no effect after two weeks.

With NALED the results were not satisfactory.

Figure 2 is a picture of five "standard sets" of containers as they were set up for

FIG. 2.—Five "standard sets" of artificial containers that are common breeding places of *Aedes aegypti* in the Caribbean area, as used by the cooperative Aedes Aegypti Testing Laboratory at Kingston, Jamaica, to evaluate candidate larvicides for use in *aegypti* eradication operations in the Caribbean area.

study in a garage stall in Kingston. It was found essential to protect the containers from inquisitive people and animals, as well as from falling leaves, and the arrangement here shown proved to be satisfactory.

Abedi and Aarons made some additional studies on their containers 21 weeks after they had been charged with the larvicides. Some of the containers had wild *aegypti* larvae in them, and were not studied further. In the others a limited bio-assay was made by introducing 50 *aegypti* larvae of the test strain into each of the containers and observing the mortality. There was good correlation between the residual effect 21 weeks after the containers had been charged, and the observations during the 12 weeks of the intensive study of the containers.

CONCLUSION. The use of the "standard set" of artificial containers is considered to represent a logical approach to the evaluation of any insecticide for use in the *aegypti* eradication operations in the Caribbean area.

The problem that needs an urgent solution in the Caribbean area is: what insecticide to use in place of DDT in areas in which *aegypti* is resistant to both DDT and dieldrin. In the Caribbean, much thought must be given to the insecticide for use in drinking water, because in that area *aegypti* frequently breeds in drinking water.

The results here presented indicate that there is no single insecticide that is available at the present time. Therefore, recourse may have to be had to a battery of perhaps three insectides, namely:

Dimethrin for use in drinking water—because it is tasteless and non-toxic.

Malathion, or trichlorfon, should be satisfactory, if they can be applied once a month, in the general run of artificial containers.

Paris green, used for many years in Dade County, Florida, is a reasonably permanent treatment for discarded automobile tires—which are artificial tree holes—and important primary breeding place of *aegypti*.

This small battery of insecticides would not weigh more than a man could easily carry all day.

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The **National Mosquito Control Fish and Wildlife Management Coordination Committee** has been engaged for some time in organizing the **"First Gulf Conference on Mosquito Supression and Wildlife Management."** The Conference is being sponsored by the Louisiana Mosquito Control Association, Louisiana State Board of Health, The Florida Anti-mosquito Association, Texas Mosquito Control Association and the National Mosquito Control Fish and Wildlife Coordination Committee. **The Conference will be held at the Holiday Inn, Lafayette, Louisiana on Nov. 16–18, 1964.**

This Conference should be of interest to many members of AMCA.