

ERADICATION OF THE *Aedes Aegypti* MOSQUITO FROM THE AMERICAS

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I—TECHNICAL EVOLUTION OF THE CAMPAIGN

The discovery of jungle yellow fever gave rise to the idea of eradicating *Aedes aegypti*. The results obtained in 1930 in the Rio de Janeiro campaign and those that were being achieved since 1923 by the Rockefeller Foundation in other Atlantic port cities of Brazil, led to the belief that the solution of the problem which arose with the discovery of the yellow fever virus in the South American forests would be possible only with the absolute eradication of the urban vector-mosquito of the disease, since the palliative control measures were no longer justified. Working standards were instituted on the basis of (a) wise administration; (b) strict execution of the measures recommended by experience, with the compulsory use of petroleum in all deposits with foci; (c) organization of supplementary services to discover residual foci, as indicated by the capture of adults, a method that was being used against malaria and thereafter became essential to the evaluation of the anti-*aegypti*

work. With the use of these three basic measures, evidence was gained that *Aedes aegypti* could be eradicated in Brazil with a few more years of work, if certain aspects of the problem that had been disclosed by experience were solved. The first revelation was that the success of the campaign in Brazilian port cities depended upon the application of the control measures to all other localities maintaining sea, river, or land communication with such cities, necessitating an extension of the work to the suburbs and later as far into the rural areas as *Aedes aegypti* was found. There were regions in Brazil in which the mosquito had spread to such an extent, as was the case in the northeast, that it was necessary to cover such regions in their entirety, just as if they were a single "ever-increasing adjacent area."

Another difficulty that had to be overcome was the resistance of the *Aedes aegypti* egg to desiccation and, in general, to temperatures biologically unsuitable to other species of mosquitoes. This resistance, which is known to reach 450 days in laboratory, amounts to an average of more than a year under natural conditions. This is one of the factors on which the criterion of *Aedes aegypti* eradication is based, and we shall take up this point later. The

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campaign that was proceeding in Brazil under the guidance of the Rockefeller Foundation was not limited to that country alone. It was extended to Bolivia, Paraguay, Peru, and Colombia, giving the same good results and showing that the eradication of *Aedes aegypti* was to be considered a project no longer limited to national boundaries but rather one continent-wide in scope.

In 1940 an event occurred that convinced even the most skeptical persons of the idea of eradicating a species of mosquito. *Anopheles (Myzomia) gambiae*, which came from Africa and was discovered in 1930 by Shannon at Natal, in Rio Grande do Norte, Brazil, had been poorly combated and succeeded in penetrating a vast area of that State and of the State of Ceará, causing great epidemics of malaria in 1938 and 1939 and creating a problem that to many malariologists seemed unsolvable. The vector was, however, conquered and eradicated in Brazil that year in a memorable campaign conducted under the guidance of the Rockefeller Foundation, using the same basic principles of organization and discipline and a large group of persons who had been working actively in eradicating *Aedes aegypti*.

The strategy used against *An. gambiae* was planned according to the living conditions that the mosquito had to adopt in order to survive and spread in northeast Brazil, these conditions being very similar to those of *Aedes aegypti* owing to the domestic habits of the adult and its preference for small collections of water. The attack was based on the systematic use of paris green in all collections of water, and on fumigation with a compound based on pyrethrum and carbon tetrachloride in a kerosene solution (PTQ). Repeated treatments were applied to all houses so as to eliminate the greatest number of adults possible, using a De Vilbiss sprayer quite similar to those used today in DDT sprayings. Inspection was maintained of innumerable collections of water that formed, and of pools that appeared in dry river

beds and were used for irrigation or for watering animals. At the same time intradomestic captures were made in order to evaluate the results of the measures adopted. The eradication of *Anopheles gambiae* in Brazil demonstrated that the experience acquired and the personnel employed in the campaign against one insect vector of disease could be utilized in combating other vectors, an idea that anticipated the theory of coordinated campaigns which came about with the discovery of residual-action insecticides.

With the advent of DDT the time arrived to give more serious thought to the eradication of *Aedes aegypti* on a continent-wide scale. With the withdrawal of the Rockefeller Foundation from yellow fever work, the Pan American Sanitary Bureau, which had undergone a complete reorganization in 1947, inherited the responsibility for the problem. It was evident that the point demanding first attention was the eradication campaign. On the other hand, it was realized that the program that had been under way in Brazil for a number of years could not achieve complete success unless the country's frontiers and ports were fully protected against constant *Aedes aegypti* reinfestation. It became essential to pursue on a continental scale the work that had been done within the country. In other words, an attempt had to be made to extend the campaign to neighboring countries, all countries with which communication was maintained, until the threat of reinfestation disappeared.

DDT, used as a larvicide merely to substitute for petroleum, would have done little to advance the campaign. It was apparent from the start that DDT could be used systematically, because of its innocuousness to man in recommended dosages, in possible breeding sites with or without water as a protection against new foci, a protection achieved previously through complicated mechanical processes.

This method facilitated the use of the insecticide, since the worker had only to carry a container with the solution, emul-

sion, or suspension of DDT at 3 percent to 5 percent in order to make the application, but it has the disadvantage of attacking the mosquito only in its larval stage, thereby making little use of the residual action of the insecticide, for the organic matter usually found in home water deposits tends to reduce and even to eliminate its residual power. It was felt that the over-all application to the inside surface of dwellings, a method used in combating malaria vectors and certainly capable of eliminating all possibility of *Aedes aegypti* survival, particularly when DDT is applied also to all the dwelling's containers would be too expensive and time-consuming in a campaign that, owing to its very nature, should be intensive and rapid. Therefore, preference was given to a process that was not so extensive or so expensive but could give effective results by using measures adapted to the biology of the *Aedes aegypti*. It was thus decided that DDT should be applied in solution, emulsion, or suspension of from 3 percent to 5 percent, using a small sprayer, to both the outside and inside of all possible breeding sites, with or without water, and to a section of the nearby wall, so as to eliminate the existing foci and prevent the formation of other foci by destroying the female adults seeking to lay their eggs. This simple and economical method, which we call perifocal because it reaches the *Aedes aegypti* in their microclimate, was adopted by the Pan American Sanitary Bureau beginning in 1948, after confirmation of its effectiveness in the field.

Experience has demonstrated that with the perifocal method, (a) one well-applied DDT treatment eliminates *Aedes aegypti* from small localities (less than one thousand houses) where, generally, there is no problem of hidden foci or foci difficult to reach; (b) normally, two DDT applications during a year are sufficient to solve the problem in average localities (from one to five thousand houses); (c) four carefully made applications of DDT to all infested points in a large city (over five thousand houses), at intervals of three

months, are sufficient to free it from *Aedes aegypti*. An effort was made to adapt the campaign to new working standards developed with the use of DDT, taking the greatest advantage possible from the experience derived from petroleum. Since the action of DDT as we have used it provides safety for at least three months, it was possible to extend the minimal visiting cycles to that period, thereby effecting considerable economies in the campaign. Moreover, as the insecticides came to be used systematically in all possible breeding sites, with or without water, providing an even greater margin of safety, it was possible also to make a considerable reduction in the complementary services concerning closed and uninhabited dwellings, and almost to discontinue the special inspection of inaccessible deposits, control of cemeteries, and cleaning of vacant lots. Nor was it necessary to maintain the compulsory application of the law by the use of writs of infraction and fines, other than for those cases in which permission was not given to make house inspections and appropriate applications of DDT.

Other measures that have gained even greater importance with the use of DDT are the search for breeding foci difficult to reach, making captures that lead to such foci, and the compulsory use of the capture method as the final word in proving the eradication of the species in urban areas.

Another important modification that did much to simplify former ideas in this regard, was in the method of determining indices, which formerly were in every third house in all city blocks in the locality, whereas today it suffices to check every third house until the first positive one is found in each block. In small localities in rural areas it is sufficient to find one focus in order to determine what measures should be taken to eradicate the *Aedes aegypti*. The new system adopted in this regard does not permit learning the degree of infestation, but it is sufficient to serve as a guide for using DDT.

With the reduction of the complementary services and practical discontinuance

of the special services, the number of forms used to record data and to note down the measures taken was greatly decreased. From the more than one hundred forms used previously, less than ten essential ones are now being utilized.

Requirements that have not been relaxed but have been made even more rigid are those referring to the use of sketches and itineraries to direct the work in the field, to the need for demarcating work areas for each inspector, and, particularly, to the repeated and timely check work carried out not only by the chief inspectors but also by the chief or director of the campaign. The requirement also stands with respect to the use of flags to indicate the presence of an inspector or chief inspector in the house being worked and, in addition, the field personnel still must use uniforms to facilitate their work and to permit their ready identification.

After some years of experience in campaigns based on DDT, it was possible to formulate standards governing techniques and evaluation of results, these being contained in the "Guide for the Preparation of Reports on the *Aedes aegypti* Eradication Campaign in the Americas," distributed by the Pan American Sanitary Bureau in January 1954 which is being revised now. This Guide describes the two basic reporting forms, a monthly one containing data for publication in the Bulletin of the Pan American Sanitary Bureau, and a quarterly form showing data on the initial and the present conditions in all localities found with *Aedes aegypti* in each country. With such data it has been possible to evaluate correctly the results of the anti-*aegypti* campaign in the countries and territories where work is under way. A direct appraisal of the activities is made by advisers and inspectors maintained by the Pan American Sanitary Bureau in the countries to instruct the local personnel and to follow up and intensify the work.

The culminating result of the use of the aforesaid standards and of the experience we have gained with the development of

the anti-*aegypti* campaign in the Continent, is the criterion established for proving the eradication of the mosquito, which, along with general lines, can be described as follows: Taking as relevant factors the average period that the mosquito egg resists desiccation, or about one year, and the probable duration of the residual action of DDT, estimated at three months, it has been proved that it is necessary to repeat the examination of the results in cycles, according to this residual action and within the average period that the egg is resistant. This procedure has in view to discover possible flaws in the techniques used and to permit greater reliability in the data presented, especially when the last examination is confirmed by search for capture of adults at the time the search for foci is made, in accordance with the standards adopted.

The eradication criterion for urban areas where the *Aedes aegypti* finds all conditions favorable to survival should be as rigorous as possible, and there should not be less than two consecutive negative checks, through search for foci and for capture of adults, so as to confirm the absence of the mosquito for a period of at least one year after the last focus or the last adult was found.

In rural areas where living conditions are usually very precarious for *Aedes aegypti* and there are no problems concerning breeding places difficult to reach and ovular resistance can be overcome relatively easily, eradication should be confirmed after a negative check by foci search in the total number of houses at least one year after the last focus was found in the area.

Taking into account the data that are presented by the various countries and the direct appraisal of the field work, a periodic evaluation is made of the results obtained in the anti-*aegypti* campaign in the Americas, with a view to intensifying and improving it and to proving the eradication of the species according to the established criterion.

II. ACTUAL STATUS OF THE CAMPAIGN

The progress made in the *Aedes aegypti* eradication campaign in the Continent is reflected in the attached map, based on reports until December 1955 and on first-hand observation of the problem in each country. The results can be summarized as follows:

SOUTH AMERICA. The vast area in eastern and northeastern Brazil treated for many years with petroleum, was shown in 1952, after four years of systematic DDT work, to be almost completely clean, and only the final checks are lacking to prove eradication of *Aedes aegypti* throughout the country. The problem in Brazil, because of the country's area and the existence of conditions favorable to the mosquito, undoubtedly represents one half of the problem in the Continent. Bolivia, in 1948, was the first country to be freed of the mosquito; French Guiana followed in 1952. Chile, Ecuador, British Guiana, Paraguay, Peru, and Uruguay, in that region of the Continent, are in the final stages of eradication. Argentina is now organizing a nationwide campaign. In Colombia and Venezuela the work continues and is being intensified in Venezuela after the recent jungle virus threat. Surinam is the only part of South America where the campaign has not yet been started.

CENTRAL AMERICA. Subject to the results of the last checks now being made, Panama, Nicaragua, Costa Rica, Honduras, and British Honduras can be considered to be in the final stages of their campaigns. The campaign was intensified recently in El Salvador and Guatemala and the final stage should be reached next year. *Aedes aegypti* is considered to be eradicated in the Panama Canal Zone (U.S.A.), although no statistical data are available to corroborate this fact.

GREATER ANTILLES. Generally speaking, the situation in these islands is still not satisfactory. Cuba, where the idea of combating *Aedes aegypti* originated, is quite infested as was revealed by the first results of the campaign initiated in March 1954.

In the Dominican Republic the situation is better in the interior than in the capital, where it has not yet been possible to apply all the necessary measures. Nor has Haiti succeeded in developing a rapid plan of work. Jamaica is still infested, but measures are being taken to improve the campaign. Good results are being obtained in Puerto Rico with the measures adopted to accelerate the eradication of *Ae. aegypti*.

LESSER ANTILLES. In most of these small islands the campaign was initiated recently and there is a trend to extend them to the others. They include thirteen archipelagos, in ten of which *Aedes aegypti* work is already being conducted, although not always in satisfactory fashion. With respect to the spread of the mosquito, Trinidad, Tobago, and the Netherlands West Indies (Curaçao, Aruba and Bonaire) are the most important points and they are now adopting measures that should result in the speedy elimination of the *Aedes aegypti*. In Trinidad an outbreak of yellow fever occurred in 1954, when the virus invaded Port-of-Spain, producing *Aedes aegypti*-transmitted cases, a situation that had not occurred in the Americas for over twelve years.

NORTH AMERICA. In Mexico, the campaign was interrupted in 1955 but it is possible that it will soon be resumed. There are large infested areas in that country, particularly in the Yucatan Peninsula and along the Atlantic and Pacific coasts. It is expected that the recently initiated malaria-eradication campaign, with the application of DDT to large areas where the two problems coexist, will contribute much toward eliminating *Aedes aegypti*.

Special reference should be made to the United States, the only country that has not initiated an *Aedes aegypti* eradication campaign. Ponderable reasons, some acceptable, others unjustifiable, have been postponing the start of the campaign in this country, which is in a position to carry it out quickly and brilliantly. The problem has more of a psychological basis and is difficult to solve from a political



FIGURE 1

viewpoint. In view of the vast area considered as yellow-fever receptive by the Public Health Service, an area that includes parts or all of thirteen states in the south of the country, the task would be a difficult one to undertake, particularly in its initial stage, but there are many factors that tend to facilitate the campaign. Among them we can point out the interest being shown by the Communicable Disease Center and the willingness of the Government to make a study of the problem, beginning at the important seaports.

In the meeting of last November in Kansas City the American Public Health Association approved a resolution urging that "the United States Public Health Service and the State Health Departments take immediate steps to initiate programs directed toward the eradication of *Aedes*

aegypti mosquitoes from the United States." This campaign, more than ever before, needs for its rapid conclusion, that a favourable decision be taken by the sanitary authorities of this country.

Last year in the meeting held in Panama City, Florida, the Director of the Pan American Sanitary Bureau emphasized the importance of the support of this Association and the members of the Association, not only for such things as the eradication of *aegypti* but also for other functions such as international organizations, part of the general world movement of better international understanding. It is with this purpose in mind that I address you now, certain of the great interest that this campaign has aroused and also of the support of all members of this Association.