

RECENT TRENDS IN MALARIA CONTROL IN LATIN AMERICA

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INTRODUCTION

During the period of 1942-1946 the author was assigned as Chief of Field Party of the Institute of Inter-American Affairs to El Salvador, C. A., for one year and, subsequently, for three years to

Mexico. During the former experience, opportunity was afforded for visits to other Central American countries. More recently the International Health Division of the Rockefeller Foundation made possible a tour of malaria control activities in certain Caribbean and South American

countries, including Trinidad, Venezuela, Colombia, and Panama.

Undoubtedly World War II provided a great incentive for investigations on the possibilities of control of malaria. The discoveries of more effective insecticides, such as DDT, gammexane, 1068, et cetera, the application of these materials as adulticides in the form of residual house sprays, and the combined efforts under the Committee for Coordination of Malaria Studies in the research for new chemotherapeutics have permitted rapid strides in malaria control work during this interval.

MALARIA PROBLEM IN LATIN AMERICA

The special conditions existing in tropical regions of the world contribute toward increasing the malaria problem as compared to that existing in more temperate climates. Some of these contributing factors are unusually heavy seasonal rains, the widespread use of irrigation, poor housing and poor nutrition, the almost universally low economy, and frequently the year-round breeding season of the vector. Faust (1941) in discussing the distribution of malaria in Mexico, Central America, and the West Indies states that the computed average malaria mortality rate for all of the tropical countries considered in his paper (with a reported population of 38,500,000) is 166 per 100,000 population, a figure probably far too low. This means that approximately 63,900 deaths are caused each year by malaria in this region.

The writer was greatly surprised shortly after his arrival in El Salvador in making malaria surveys in company with Dr. Arnaldo Sutter to encounter spleen rates of 88 per cent in Acajutla and 83 per cent in Sonsonate during the dry season (March). Parasite rates were 36 per cent and 26 per cent respectively. Not only were these rates high, but a considerable portion of the cases of splenomegaly were in classes 3 and 4, with very few PDI or in class 1. In neither of these communities was there evidence of epidemic malaria at the time of the survey. Subsequently,

there was an experience in Mexico where, following a tornado in September 1944, widespread malaria epidemics occurred in the region of the Isthmus of Tehuantepec and the coastal portions of the State of Veracruz, which also emphasized the importance of the disease. The prompt utilization of atabrine as a therapeutic and prophylactic permitted the rehabilitation of the damaged areas.

It is still generally admitted that in the tropical Americas malaria is public health problem No. 1, despite the fact that notable progress has been made in recent years and that the future is very promising.

EARLY DEVELOPMENTS IN MALARIA CONTROL IN LATIN AMERICA

The experience gained in the construction of the Panama Canal shortly after the beginning of the present century demonstrated that while malaria is a terrible scourge which, if uncontrolled, may frustrate man's plans, it can be brought under control by appropriate measures, carefully enforced. The maintenance of control procedures has been demonstrated as feasible in this location. The historical experience in Panama has not been accompanied, however, with very significant similar efforts in adjoining regions. Undoubtedly the high cost of these control measures has not permitted their widespread application.

In connection with drainage for malaria control the experience in Panama has been very fruitful. The widespread utilization of permanent ditch lining has progressed to the point that the "Panama" invert has been adopted in many other places.

CONTROL

1. *Permanent Elimination of Breeding Places*

(A) *Drainage*

As referred to above, the necessity for utilization of some form of permanent ditch lining has been adequately demonstrated in Panama. The utilization of precast or cast-in-place structures for the permanent lining of drainage canals is of

great importance in the tropics. Excessive rainfall which may be of short duration, combined with fertile soil, makes their use imperative in lieu of costly continuing maintenance.

Along with the necessity for permanent ditch lining, there are a number of special requirements which must be utilized under particular circumstances; to mention only a few, the question of the sodding of the slopes of ditches, the clearing of right-of-way to prevent vegetation from overgrowing the canals, and the provision of overpasses for livestock and carts, or special crossings.

In many instances it is possible to combine agricultural drainage or land reclamation with malaria control drainage. The removal of storm water or sewage can frequently be integrated with malaria control drainage. The city of Maracay, Venezuela, demonstrates an excellent example of the expansion of residential districts made possible through drainage of swamps. At Sonsonate in El Salvador irrigation was combined with malaria control drainage, a project undertaken by the Servicio Cooperativo Inter-Americano de Salud Publica. In this region the transmission of malaria was occurring on a year-round basis through the production of *Anopheles albimanus* in ponded areas during the wet season and was associated in the dry season with the use of irrigation water where adequate provision was not made for the run-off of the surplus. It was possible to design the canals so that they are utilized for drainage purposes during the rainy season and to carry water from a spring to be used for irrigation purposes in the dry season, but it was necessary to provide for the carry-off of the residual from excessive irrigation.

In Venezuela the opportunity to combine highway drainage and malaria control drainage was observed recently near Valencia. Here, as in other instances, the initiative was taken by the Health Department rather than by highway construction.

Special situations, such as the utilization

of construction of drainage outlets across sand bars, have necessitated the protection of the outlet to the sea. Newbold (1943) has described a sea head for coastal swamp drainage. The sea head projects into the sea with two side openings at right angles to the long axis of the structure. The scouring action of the waves keeps the outlet unobstructed and free of sand. An example recently seen at Patience Bay, Trinidad, was functioning satisfactorily.

(B) *Diking and Dewatering*

The construction of dikes and the installation of pumps to dewater the diked area has been utilized in various parts of the world as a malaria control procedure. It is particularly applicable in coastal areas where sufficient gradient is not available for gravity drainage. During the recent years there has been considerable extension of this measure on the island of Puerto Rico.

(C) *Filling*

As mentioned above, the town of Acajutla, El Salvador, has an intense malaria problem which in certain surveys has been revealed as high as 96 per cent splenomegaly among the school children. This town with a population of approximately 1,500 has had previous to 1942 more deaths than births. The principal cause of mortality was malaria. This important port maintained its population through immigration, but the supply of labor was constantly being decimated through malaria. The principal sources of *A. albimanus* breeding were fresh-water ponds in the rear of the sand bar on which the town is located. Through a cooperative arrangement with the railway and port authorities, the Servicio Cooperativo undertook the filling of these breeding places. Atabrine was administered temporarily to the labor forces. Even prior to the completion of the filling work, a marked improvement in labor was noticeable, and it is believed that extension of the work would practically eliminate the vector from this town.

Filling has been used quite extensively in many countries of Latin America. In Panama in connection with the excavation for the canal extensive swamps were filled. More recently in Venezuela this malaria control measure has been utilized at Ocumare de la Costa and previously in Turriama.

Not only does this measure result in the permanent elimination of breeding places of the malaria vector, but it also leads to land reclamation which may play a very important part in the development of cities. One of the largest projects under consideration is about to be initiated in Barranquilla, Colombia, where an area adjoining the river extending for several miles is at present flooded during the major portion of the wet season, resulting in heavy production of *Anopheles albimanus* and preventing the proper industrial development along the river front. The increase in land values will more than repay the anticipated cost of the hydraulic fill of this particular project.

Although not extensively utilized to date, proper disposal of garbage through sanitary fill may be used to eliminate extensive swamps about cities. This sanitary procedure, however, must be carefully controlled, or it may lead to the creation of a health nuisance.

2. Larvicides

While scientifically conducted experiments with oil as a larvicide were first published by Howard in 1892, probably the earliest wide-scale demonstration of their application in malaria control was made in Panama during construction days of the canal. The formula utilized there was as follows:

200 lbs. of finely crushed resin mixed with 15 gallons of crude carbolic acid; 30 lbs. of caustic soda dissolved in 6 gallons of water are added to form an emulsion.

Various formulas of oil have been utilized in Latin America, particularly in countries having petroleum deposits. The repetitive, costly nature of this procedure has prevented its wide adoption.

Similarly, Paris green has been used as an anopheline larvicide and is still being used today as, for example, in Panama, where the cost of weekly applications has prevented its widespread use.

The discovery of DDT as a larvicide led to its prompt adoption, and some of the earliest work in the distribution of DDT by airplane was carried out in field tests in the Canal Zone during the recent world war. Despite the fact that it is cheaper and more effective than the older established larvicides, so far as is known it has not yet been adopted in extensive Latin American areas.

3. DDT Residual House Sprays

Following the field trial of DDT in the United States, as reported by Gahan and Lindquist (1945), at Stuttgart, Arkansas, the effectiveness of DDT residual spray, in a rice-growing area in Mexico where *Anopheles pseudopunctipennis* is the vector, was tested by Gahan and Payne (1945). These latter authors found that not only was there a marked reduction (99.9 per cent) in the number of adult mosquitoes in the treated area but there was also a considerable reduction (89 per cent) in the larvae in the breeding grounds immediately adjacent to the treated region as compared with untreated control villages.

Trapido (1946) reports upon the effect of residual spraying of dwellings with DDT in the control of malaria transmission in Panama, with special reference to *A. albimanus*, as carried out in a highly malarious area which has been under continuous study for 15 years and where conditions are excellent for the sustained production of large numbers of the malaria vector. *A. albimanus* does not normally rest in houses during the daytime. In this experiment the exterior and the interior of all dwellings (native huts) were sprayed. The study revealed that not only was there a large reduction in the numbers of mosquitoes in treated dwellings, but also that among those taken in these dwellings there was a marked reduc-

tion in the percentage engorged (since DDT activates the insect and it loses interest in feeding) and that among the engorged mosquitoes the 24-hour survival rate was low for a period of 3 months after treatment. A marked decline in the malaria rate was observed, the cumulative index being 14.8 per cent for the year 1945 in the sprayed village and 52 per cent for the same one-year period in the control villages.

Stephens and Pratt (1947) present the results of their first year's observations of DDT residual spraying of a village in Puerto Rico. In the treated village there was a progressive decline in the percentage of positive malaria slides from 5.8 per cent in the "rainy season" of October, 1944, to 2.8 per cent in the dry season of March, 1945, and, most significantly of all, to 0.91 per cent during the "rainy season" of October, 1945. The control village followed approximately the normal cycle for Puerto Rico with 4.7 per cent positive for malaria during the "rainy season" of November, 1944, decreasing to 0.51 per cent positive during the "dry season" of March-April, 1945, having a marked increase to 3.8 per cent positive during the "rainy season" of November, 1945. In the treated village the first residual spraying was done in November, 1944, and the second in June, 1945.

Extensive investigation of the efficacy of DDT as a malaria control procedure has been observed recently in Trinidad, Venezuela, Colombia, and Panama. It is known to be under investigation in a great many other countries of tropical America. This new approach to the control of the vector offers for the first time an adequate measure applicable to a wide variety of conditions, not prohibitively expensive, enthusiastically received by the public, and providing wide utility in a public health program, including the control of flies, *Culicoides*, *Phlebotomus*, lice, fleas, and other arthropods important in the transmission of disease. In small towns and rural areas where the permanent elimination of breeding places can-

not be undertaken in view of its cost, DDT as a residual spray would seem to hold greater promise than any other malaria control procedure developed to date.

4. *Herbicidal Work*

Recent interest in the United States in the application of hormone type herbicides, such as 2,4-D, for the control of aquatic vegetation is particularly promising in the field of malaria control (Hall and Hess, 1947). Its applicability to tropical conditions apparently has not been adequately tested.

One instance of reliance on herbicides as a malaria control procedure may be cited from Trinidad. Extensive use is being made of $\frac{1}{2}$ per cent solution of copper sulphate in the control of epiphytic plants which harbor *Anopheles bellator*. The immortal trees in the cacao-producing area of Trinidad harbor large numbers of bromeliads. One particular species of *Gravisia* frequently harbors *A. bellator*. The selective spraying of this bromeliad utilizing the gypsy moth sprayer has given satisfactory results. While the treatment is expensive, it has a rather lasting value. No regeneration has been reported over a period of 5 years.

5. *Naturalistic Measures*

Carr (1938) in Cuba experimented with the possibility of limiting *A. albimanus* breeding by shading the streams. He states that natural bodies of water which are well shaded and which are provided with predacious fish are unfavorable for mosquito breeding, due to the fact that horizontal and other vegetation does not flourish under these conditions and, therefore, the larvae have no protection against their natural enemies. He utilized *Ficus benjamini* for the production of shade. He also produced artificial shade by constructing a palm leaf thatched roof over a section of a small stream. Prolific *albimanus* breeding was present in floating algae at the initiation of the experiment. After the roof had been in place for one

month, the filamentous algae and anopheline larvae had disappeared from the shaded portion of the stream.

It does not appear that any extensive utilization has been made of the introduction of artificial shade in the control of malaria mosquitoes in Latin America. It is, however, a frequent observation that densely shaded areas, such as heavy growth of sugar cane, may not prove attractive to certain anopheline vectors in this region of the world.

Earle studied the utilization of intermittent irrigation of rice fields in Mexico as a control measure for *Anopheles pseudo-punctipennis*. It was found that where the cooperation of the rice farmers could be enlisted the procedure was effective in the prevention of the transmission of malaria. As a result of these investigations, certain legislation was adopted either restricting the growing of rice in close proximity to densely populated areas or requiring the employment of intermittent irrigation so that a period of drying of sufficient length to kill the anopheline larvae resulted.

Other naturalistic measures have received considerable study in Latin America. The employment of predacious fish, such as *Gambusia*, has probably been most widely adopted. In general, however, it seems that the employment of naturalistic measures is of rather limited utilization and has never been widely adopted for a variety of breeding situations.

Certain use of automatic siphons has been made in Latin America (e.g. in Granada, Cochrane and Newbold, 1943). In Trinidad in one situation a dam and automatic siphon have been constructed to produce a flushing out of a stream in control of mosquito breeding. This particular siphon has been designed to provide flushing of the stream during the dry season when pooling of water in the stream bed creates satisfactory breeding places for *A. aquasalis*. The initial installation was stated to cost approximately \$3,000, and effective flushing range of 2½ miles downstream from the siphon is provided.

6. Chemotherapy and Chemoprophylaxis

Clark and Komp (1941) over a period of 10 years carried out an experiment in the control of malaria with drugs alone where no antimosquito measures were used. While it was shown that the average annual rate for the treated villages showed a decline from 21.6 per cent to 12.1 per cent over the 10-year period and that a comparable decrease was not noted in the control groups, the study brought out the limitations of relying on drugs alone in the control of malaria. In the authors' opinion, quinine sulphate and atabrine were of equal therapeutic value.

During the war a total in excess of 12,000 drugs were tested as antimalarials, and as a result of these investigations two or three show considerable promise. In the Americas the most critical tests have been carried out with chloroquine. Chloroquine as a suppressive appears to be at least as effective as atabrine when administered as one pill (0.15 grams) once weekly. Furthermore, it has the decided therapeutic advantage that a course of treatment does not exceed 3 days' duration and is not accompanied by any discoloration of the skin. Experimentation that is now in progress with this drug in Panama, Colombia, and other Latin American countries will undoubtedly point to the exact place which this drug may assume in a malaria control program. In highly endemic areas it would seem that some consideration to the treatment of the "seed bed" of malaria must be given in addition to the utilization of DDT house residual spray. If this is not given, the individuals will continue ill of malaria and subsequently may have numerous relapses, particularly in the case of tertian or quartan malaria. On the other hand, if a single course of treatment can be administered over a 3-day period and some minimum provision be made for the follow-up either through weekly suppressive dosage or for retreatment of those who break through with relapses, the antimosquito measures, such as DDT residual spray, may be relied upon to prevent new transmission of malaria.

SURVEYS

Information on the distribution of anophelines in Latin America has been accumulated over a period of years. Rozeboom (1941) summarized the distribution data concerning *Anopheles* mosquitoes of the Caribbean area. In the United States information on the distribution of *A. quadrimaculatus* can readily be obtained from inspections of stables or dwelling places. In Latin America, with the exception of a few species, such as *A. darlingi*, many of the important vectors do not rest during the daytime in dwellings. It has, therefore, been necessary to make extensive use of various types of traps. The animal-baited traps devised by Earle, Magoon, and others have been particularly effective as regards captures of *A. albimanus*. The "Shannon-dawn" trap as observed in Trinidad has certain advantages over the former types of traps. In the island of Trinidad it has proven particularly helpful in the capture of *A. aquasalis*. Data from Puerto Rico and Colombia indicate that the New Jersey light trap may be useful in determining density of *A. albimanus*.

RESEARCH

Until recent years research on malaria in Latin America has been mainly limited to surveys to define the malaria problem and to incriminate the local vector. Neither funds nor trained personnel were available for the basic research which forms such an important part of malaria control programs. Through the cooperation of the International Health Division of the Rockefeller Foundation and more recently the Institute of Inter-American Affairs, local Health Departments in Latin America have been able to devote much more attention to basic research. It is believed that more careful investigations will not only lead to a better definition of the problem but will also evolve more effective means to resolve it.

No attempt within the scope of this present paper will be made to summarize the very extensive dissection studies that

have been carried on in Latin America to incriminate the various anopheline vectors of malaria. In the main, it may be stated that a certain amount of information is available concerning the percentage of the suspected vectors positive upon examination of stomachs and glands. In certain individual countries it may be said that this information is relatively adequate. On the other hand, in other places it is totally inadequate.

Similar statements may be made about the blood and spleen surveys for malaria. The activity of the International Health Division of the Rockefeller Foundation and, during the last 5 years, of the Institute of Inter-American Affairs has given great assistance to the individual countries in determining the exact status of malaria.

TRAINING

The Dirección de la Malariología of Venezuela has excellent facilities for training in its headquarters building in Maracay. Adequate classroom and rather complete laboratory facilities for 32 students are available. Annually one formal course of 4 or 5 months' duration is given at Maracay, followed by field training for doctors, engineers, and inspectors. Venezuela has accepted trainees from other Latin American countries, and the facilities are excellent for this purpose. The advantages of instruction to students in the Spanish language and in an environment similar to that in their own country are obvious.

At the Institute of Tropical Medicine in Mexico City there are excellent facilities for research. Recently interest has been aroused in training in tropical medicine, and a special course of malariology has been given at times. There are splendid opportunities in Mexico also for field training, particularly since special centers, such as the Boca del Rio Health Center and Tropical Medicine Training Station and the Onchocerca Center at Huixtla, have field demonstration and training facilities.

The Puerto Rico School of Tropical Medicine and Public Health also provides opportunities for training in general tropical medicine.

It is to be hoped that more countries of Latin America will begin to provide facilities for the training of their own personnel and possibly for the reception of trainees from adjoining countries which do not have these facilities.

FUTURE OUTLOOK

In a considerable number of countries of Latin America real progress has been made in the control of malaria about the important cities and larger towns. In the main, this has been through permanent elimination of breeding places of mosquito larvae. Less attention has been given to the smaller towns and rural areas. The advent of DDT residual spray is a promising event for these more sparsely populated areas. The exact place of this measure in the prevention of the transmission of malaria probably remains to be defined. It appears certain that this procedure will have many beneficial side effects through control of other arthropods which are vectors of disease in the tropics. The availability of certain of the new chemotherapeutics and chemoprophylactics is increasingly promising. Again, the exact position that they may attain in a general malaria control program has not yet been delineated. The increasing attention being focused on research in the field of malariology is one of the most promising fields of development in the American tropics today.

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