

MALARIA CONTROL IN THE DOMINICAN REPUBLIC

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The Dominican Republic occupies approximately two-thirds of the West Indies island originally called "Hispaniola" by Columbus, following the discovery of America. It is situated between Cuba and Puerto Rico and is the second largest island of the West Indies group. For the most part, the Dominican Republic is high lying, having very little coastal plain. Beginning close to the sea, rolling country gradually gives way to hills and mountains as the interior of the country is approached. The exception to this is the Lake Enriquillo Basin in the southwestern portion, which is 154 feet below sea level at the water surface of the lake. There are three distinct mountain ranges lying in a north-west to south-east plane. The highest peak is approximately 11,000 feet above sea level. Drainage from the area north of the central mountain range empties into the Atlantic Ocean and that from the southern slopes empties into the Caribbean Sea. Generally speaking, drainage is good. Swamps, fresh water lakes and lagoons are few, small in size and scattered.

The mild tropical climate found in the Dominican Republic is much the same as that in the neighboring islands. Likewise, the occurrence of malaria is similar and that disease presents a problem in almost every section of the Republic. It is commonly referred to as the No. 1 public health problem but sufficient data are not available to substantiate this opinion. Nevertheless, its importance from standpoints of public health and economy must be recognized. Malaria is present throughout the country but its prevalence varies considerably between communities.

Rainfall is plentiful in most sections, the exception being in the arid desert country in the south-west and north-west parts, where yearly precipitation ranges

from 16 inches to 25 inches. However, the rest of the country receives an abundant supply, some parts boasting a yearly precipitation of over 100 inches. As is typical of the Caribbean region, the rainy season is usually from May to October, the heaviest rains occurring in the spring and fall. Generally, there is a definite relation between rainfall and malaria incidence, the number of cases increasing during the periods of most rainfall.

In most communities, breeding places of malaria vectors are confined to streams but swamps are found in or near a few of the coastal towns. Fresh water lagoons are responsible for breeding in a few areas, the lagoons likely having been formed by geological changes in the earth's surface. In recent years, crop irrigation has become an important problem, irrigated rice fields being the principal source of trouble. An agricultural program to develop irrigation tracts is creating increased numbers of such areas and greatly aggravating the malaria problem. Sufficient legislation is lacking whereby intermittent flooding and other control measures might be required. However, a few towns have ordinances regulating irrigation practice as a means of control of malaria. These ordinances establish a "Zona de protección anti-paludica" which is the area lying two kilometers distant from the outer limits of the community. Control measures including intermittent flooding, limited storage periods for irrigation water and suitable drainage arrangements are prescribed for fields within the protected zone. The Síndico Municipal is responsible for issuance of permits and is also charged with the enforcement of the ordinance. The country boasts a health service of 26 years. However, the division of malaria in that department was

not established until 1941. Since that time, small appropriations have provided limited facilities for permanent and temporary control measures and a partially equipped laboratory for handling blood and entomological specimens. Activities of the Division have been restricted to a very small radius as a result of limited funds, lack of sufficient personnel and transportation difficulties. Permanent drainage construction by the Division has been undertaken in one community and in that instance is credited with having effected a very wholesome reduction in the malaria rate.

Through the facilities of the health division known as the "Campana Sanitaria" anti-malarial drugs are dispensed throughout the Republic to clinically diagnosed cases. Most of the drugs are used for curative purposes and not for prophylaxis. The cost of the drugs to the Department is considerable and even then it is claimed that the needs have been greater than the supply. Doubtless, the use of anti-malarial drugs has tended to suppress the incidence of the disease, and furthermore has probably interfered with case finding by blood surveys.

In August, 1943, the Institute of Inter-American Affairs, through its Executive Vice-President, Major General George C. Dunham, executed an agreement with the Dominican Republic whereby a cooperative health program was to be undertaken under the sponsorship of the two governments. Accordingly, an allotment of funds was made available by the Institute of Inter-American Affairs which was supplemented by a contribution by the Dominican Government. The cooperative health organization created thereafter is known as the "Servicio Cooperativo Interamericano de Salud Pública." For the sake of brevity, that agency is commonly referred to as the Servicio, which name will be used throughout the rest of this paper. A subsequent agreement between the two governments was executed in February, 1944, and made available additional funds from both governments, thereby expanding the program and ex-

tending the period of operation. The Dominican Republic is one of 18 Latin American countries in which this type of cooperative service is being operated. The new schedule calls for operation through the year 1947. Health projects are being formulated accordingly. Though the Second Basic Agreement stated that the Servicio funds might be used principally for malaria control purposes, it did not prohibit the operation of other types of health projects.

Servicio Drainage Projects

Malaria control drainage projects have already been undertaken in three communities in the republic. The three communities are San Cristobal, population about 5,000; Villa Duarte, section of Ciudad Trujillo, population about 10,000; and Monsenor Nouel, population about 4,000. Each project is briefly described below.

The Malaria Division of the National Health Department with the assistance of technicians from the Pan-American Sanitary Bureau provided paved drainage channels for several small streams in San Cristobal. The work was begun in May, 1941, and continued until December, 1943. Approximately 1,900 meters of channel were constructed using small crews of laborers. Panama-type inverts with masonry side walls formed the type of construction. Beginning December 16, 1943, the Servicio continued the work started by the Malaria Division and constructed 2,018 meters of paved channel in extending the paved drainage system. Of that distance, 1,080 meters of distance was paved with pre-cast inverts and masonry side walls. The remaining distance was paved with pre-cast inverts and slabs. Slab dimensions are approximately 14" x 30" x 2" with male and female joints.

The total cost of that project was \$15,498.97, not including certain services and equipment which were made available by the Dominican Government. It is thought that the following unit cost will be of interest:

	Unit cost
Excavation, M ³	\$0.48
Fill, M ³	0.50
Masonry, M ³	10.50
Inverts manufactured.....	0.47
Inverts placed.....	0.26
Slabs manufactured.....	0.17
Slabs placed.....	0.10
Cost per meter.....	7.69
Cost per man-day.....	0.71

The following quantities of work represent the accomplishments under that project:

Length in meters.....	2018.3
Excavation, M ³	3802.3
Fill, M ³	414.1
Masonry, M ³	540.5
Inverts.....	2955
Slabs.....	8073

As all minor drainage work needed in San Cristobal was not included in the project described above, a supplementary project was undertaken during September, 1944, for the purposes of completing the permanent drainage improvements. This work was completed in March, 1945. Pre-cast inverts and slabs were used in the paving of the channels. The total distance of additional paved drainage is approximately 1,100 meters. An open earth channel, 400 meters in length, was also constructed. The anopheles breeding places now remaining are restricted to a flat river with a gravel bed which changes its course frequently, thereby precluding the possibility of permanent control measures. It is proposed to combat this seasonal problem with the use of larvicides.

Permanent drainage construction was started in Villa Duarte, a section of Ciudad Trujillo, in August, 1944, the project being brought to completion early in April, 1945. Four different areas were included in the Villa Duarte project, which involve both channel construction and filling of low areas. In one flat area along the east bank of the harbor of Trujillo, one large lagoon and several smaller pools were eliminated by grading the sandy river bank between the water's edge and a steep bluff about 100 to 200 meters distant. Approximately 5,000 cubic

meters of earth was moved in that operation, all of which was done with the use of wheelbarrows.

The second area, also adjacent to the harbor, involved filling a swampy area with 2,400 meters of filling material and the construction of a channel approximately 525 meters in length.

The third area was quite similar to the second but larger, requiring more than 8,000 cubic meters of filling material. The total length of paved channel is approximately 400 meters.

Work in the fourth area consists of placing pre-cast inverts along highway ditches for improving roadside drainage. The total distance of such drains is 440 meters. These drains were placed largely for demonstration purposes in order to show officials of Public Works Department how inverts may be used along streets and roads where no curve and gutter is provided. The estimated cost of the entire project is \$18,280.00. Unit costs involved in the first two areas were as follows:

	Area No. 1	Area No. 2
Excavation, M ³	\$0.113	\$0.55
Filling, M ³	0.21	0.45
Cost per invert manufactured..	....	0.65
Cost per invert installed.....	....	0.14
Cost per slab manufactured...	....	0.21
Cost per slab installed.....	....	0.06
Rubble Masonry M ³.....	....	9.55
Cost per linear meter of completed ditch.....	....	7.55

The third town in which drainage improvements have been undertaken is Monsenor Nouel, the estimated cost of the project in that community being approximately \$32,000.00. The work which has just been started, will involve the construction of 5,876 meters of paved channel. The malaria incidence in Monsenor Nouel is very high, the number of cases increasing considerably each year during the rainy season. In November, 1944, a blood and spleen survey was made, in which 38 per cent of the smears were positive and 17½ per cent of the spleens indicated malaria.

In addition to the drainage work being undertaken, another condition exists which greatly aggravates the malaria problem. It is due to the shifting of the course of the Yuna River, resulting in the flooding of a large area adjacent to the town by a portion of the river's flow passing through a relief channel which has insufficient cross-section and insufficient drainage structures to carry the flow. The Department of Public Works has been requested to construct a retaining wall or dam sufficient to restrain the river within its normal course.

It has been customary to establish shops for precasting inverts and slabs in the town in which drainage construction is under way. In selecting a site for the shop, an attempt is made to satisfy office and warehouse needs at the same location. It is considered more economical to haul cement and other materials to the site of the invert shop than to haul pre-cast sections from one town to another. In most instances sand and gravel is available locally, which means that only cement, tools and forms need to be transported. Both invert and slab forms are portable and can be easily moved from place to place.

Following the completion of permanent drainage projects in a community by the Servicio, maintenance of channels becomes a responsibility of the Division of Malaria. However, Servicio engineers prepare maintenance schedules which are placed in operation after projects are formally turned over to the Malaria Division.

Malaria Investigations

The principal malaria vector in the Dominican Republic is *Anopheles albimanus* and it is found in all sections of the country. Other species which have been collected are *A. grabhamii* and *A. vestitipennis*. *A. grabhamii* is quite common, being found usually in shaded streams. *A. vestitipennis* is less frequently found, but specimens have been collected in swampy places covered by deep shade (identification by Blatman, 1944). In Bulletin 179, National Institute

of Health, Komp reports that *A. crucians* also have been found both in the Dominican Republic and Haiti, but he does not show in what year. Technicians of the Malaria Division suspected one recently found specimen as being *A. crucians* but unfortunately definite identification was not made. Obviously, the number of anopheline species present is small, and it may be definitely stated that *A. albimanus* presents the greatest problem from the standpoint of malaria transmission.

Prior to the establishment of the Malaria Division in the National Health Department in 1941, comparatively little study had been made of the malaria problem. There is nothing in the literature to indicate any concerted efforts having been made. During the years 1941 to 1943, laboratory facilities for handling blood smears were made available and several blood surveys were conducted. Entomological surveys were made also but they were mostly confined to sections in which large numbers of clinical cases were occurring. In March, 1944, the Servicio set up a project for handling malaria investigations. Early surveys were supervised by an entomologist of the Institute of Inter-American Affairs, who assisted in training technicians and in the establishment of a system of field and laboratory operations.

Surveys have been made by communities and in each case have included preparation of maps showing general topography, drainage courses, breeding areas, etc.; blood smears and spleen examinations of samples of the population; searches for anopheline larvae; assembling of available malaria morbidity and mortality statistics; and compilation of rainfall and other pertinent data. While the personnel of the survey group fluctuates to some extent it usually consists of two to three medical officers, one engineer, and three or more medical technicians. Frequently, other survey personnel is drawn from the Servicio engineering section for specific tasks. Field visits usually consume one week and the following week is spent in the laboratory on staining and microscopic

examination of slides, examination of entomological specimens, and preparation of maps and reports. In this way each of the personnel has an opportunity to participate in both field and laboratory work. To facilitate laboratory operations, the Servicio has provided a considerable number of laboratory improvements including microscopes, supplies, furniture, fixtures and needed materials. The improvements have greatly increased the capacity for handling specimens and better organization of work has been made possible.

Mosquito traps of the stable-type have been constructed and placed in operation in several communities, regular collections being made in order to determine the anopheline density. Burros are used as bait. Most of the traps are operated four times weekly, but in some places daily collections are made. The traps being used are of the McGoon type, except that instead of having only one central band for the entry of mosquitoes, two band slots have been provided. The openings are located at elevations of one foot and three feet above the trap base.

Complete malaria surveys were made during 1944 in 31 communities. The total number of blood and spleen surveys was 36. Of this group, the percentages of positive blood smears ranged from 0.8 to 38.0, the median being 7 per cent. The percentage positive of all smears collected was 10.1. Spleen surveys by communities indicated rates ranging from 0 to 42.8 per cent, the median being 6 per cent. The percentage of positive spleens found in all examinations was 8.1. All sections of the country are represented in the 31 communities in which surveys were made.

During 1944 a total of 13,546 blood specimens were examined in the laboratory. The number of spleen examinations made in the field was 7,550. The total number of positive blood smears was 1,374, of which 72.8 per cent showed *Plasmodium falciparum*, 17.18 per cent showed *P. vivax*, 4.73 per cent showed *P. malariae* and 5.61 showed mixed strains.

Other Anti-Malarial Measures

A larvicidal project is to be placed in operation soon. The organization, schedule arrangement, and training of personnel will be handled by the Servicio. The plan is for the Servicio to operate a larvicidal program in a community for three months and then turn over operations to the Division of Malaria for continuation. Larvicidal measures will be restricted principally to towns in which permanent control measures have been completed, and in communities in which malaria epidemics occur.

A recently established health education project is to be used to inform the public in regard to the mode of transmission of malaria and possible control measures. Some material has already been released.

Summary and Conclusions

A Public Health program on a national basis has existed in the Dominican Republic for more than a quarter century, during which time the Department functioned continuously. Just as in many other countries, the Public Health program during many of its early years was general in scope, and specialized services were largely lacking from its organization structure. In more recent years, technical divisions have been created for the purpose of pursuing problems in specialized fields. An example of this is the Malarial Division which was established in the Dominican Health Department in 1941.

During the four years of its existence, that Division has proven its right to a place in the governmental structure. Technicians have been trained and facilities have been established for the purpose of studying and combatting malaria. Early efforts to effect malaria control have already shown results and prospects are bright for program expansion in the future.

The Dominican Government in cooperation with the Institute of Inter-American Affairs have created a cooperative health agency known as the "Servicio

Cooperativo Interamericano de Salud Pública" to which funds have been made available for program operation through 1947. The Servicio has undertaken several malaria control drainage projects and a project for Malaria Investigations. A project for larvicidal control of malaria and another to provide health education facilities will support the control measures now in operation.

The malaria problem in the Dominican Republic is similar to that on other islands in the Caribbean region. The number of species of Anopheles mosquitoes found is small and *A. albimanus* is the principal vector. Entomological studies are included in malaria surveys.

The principal source of breeding is streams, but swamps, lagoons and irrigated fields are also responsible for anopheline production. Malaria is prevalent throughout the island and constitutes one of the most important public health problems. Rates vary considerably from one community to another but no community is entirely free of the disease.

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Major Caldwell graduated from the Alabama Polytechnic Institute with a B.S. in Civil Engineering and from Harvard University with an M.S. in Sanitary Engineering, and also attended Washington and Lee University, Virginia. He served three years as Director of the City Public Health Engineering program in Knoxville, Tennessee. Since October, 1942, he has served in the Sanitary Corps, A.U.S. On March 5, 1943, he reported for duty on assignment with the Division of Health and Sanitation, Institute of Inter-American Affairs.