ute spot whereas a half hour show can drag out and become very dry.

In conclusion I would like to suggest three facts to keep in mind when developing a program of this type.

First: The program is classified as a public service feature and your radio station is constantly seeking the program designed to serve the immediate community.

Secondly: Use plain layman's English. By no means get technical. And

Thirdly: Be repetitious. If we say the same thing often enough it will make the desired impression.

MALARIA IN TRINIDAD, ITS INVESTIGATION AND CONTROL . . . PAST, PRESENT AND FUTURE

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The Crown Colony of Trinidad and Tobago consists of these two islands lying within a few miles of the continent of South America off the coast of Venezuela and 10° north of the equator.

Trinidad is roughly rectangular in shape with large promontories on the northwest and southwest. The area of the island is a little more than 1,800 square miles and its greatest length is 50 miles from north to south with its greatest breadth 32 miles from east to west. The population of the Colony is given in the 1946 Census (1) as being 557,970 made up of approximately 15,000 whites, 340,000 black and coloured, 195,000 East Indians and more than 6,000 Asiatics. Port of Spain, with a population of about 110,000, is the largest city of the Colony.

Tobago is situated 18 miles away from the northeastern corner of Trinidad. It is a long and narrow island with an area of 114 square miles and a population of nearly 30,000 people.

The mean annual rainfall in Trinidad is 70 inches and in Tobago 72 inches. The population of the Colony is largely engaged in agricultural pursuits, the chief of which is the cultivation of sugar cane and cocoa. The existence, however, of the Pitch Lake and the occurrence of oil in Trinidad have given rise to a certain amount of industrialisation which is playing an increasingly important part in the economy of the Colony.

HISTORY OF MALARIA AND MALARIAL INVESTIGATIONS

Malaria was undoubtedly prevalent in both islands long before they came under the British Crown but the early records are meagre and throw little light on the subject. The capitulation of Trinidad to the British by the Spanish took place in February 1797.

At that time, a huge Spanish fleet lay at anchor under Admiral Apodaca in Chaguaramas Bay. It was unable to go into action due to the incapacitation of a great number of sailors with fever and fluxes as described by one Dr. Alexander Williams, the leading medical officer in Trinidad at the time.

The first British Governor of the Colony, Colonel Picton, who subsequently fought and died at Waterloo, reported the occurrence of a considerable amount of slow fevers, agues and fluxes among the Garrison troops, and in 1798 recommended that the capital city be shifted from Port of Spain to the heights of St. Joseph, ten miles away. Subsequent reports indicated the continuance of a considerable amount of fever in the Colony though there are no records of any outstanding epidemics.

As recently as 1938, the amount of malaria in the Colony was alarming and the disease then constituted the major public health problem of the Colony. The number of admissions of malaria to the Colonial Hospital in Port of Spain in the five-year period from 1929 to 1933 was a little more than 5,000 cases of malaria and 38 cases of black water fever (2). In the period 1934 to 1938, approximately 6,500 cases of malaria and 42 cases of black water fever (3) were admitted to this institution. In the period from 1947 to 1950, however, the number of cases of malaria admitted was 1,105 with no records of any case of black water fever (4).

The annual number of deaths from malaria as reported by the Registrar General (5) have shown a considerable decline. In 1931, 740 deaths were recorded, in 1941, 493 and in 1951, 136.

With the establishment of the role of the *Anopheles* mosquito in the transmission of malaria at the commencement of the century, the local Health Department began to devote much time and study to the mosquitoes of Trinidad and Tobago. In 1901, the Secretary of State for the Colonies drew attention to the advisability of instructing the public with regard to the relation of malaria to the mosquito and instituting precautionary measures against contracting this disease. In 1908, antimalarial measures were specifically recorded for the first time. Boyce (6) in his "Health Progress and Administration in the West Indies," published in 1909, lists five species of anophelines in the Colony and makes mention of the investigations that Mr. Urich, subsequently Entomologist to the Imperial College of Tropical Agriculture, was carrying out with regard to the anophelines of the Colony. He wrote as follows—"Mr. Urich is describing a bromelia anopheline which he thinks may be a source of malaria upon the cocoa and other plantations . . . (namely) *A. bellator*, D. & K. . . . a forest inhabiting species living only in Bromeliae. It is found in hills where there is no ground water. It is also found on cocoa estates, where Bromeliae are allowed to thrive in abundance on shade trees, common in forests all over the island and on many cocoa estates. My (Urich's) attention has often been called to the fact by country people that fever is prevalent in recently felled land: I put it down to this species and not to *A. tarsimaculata*." The number of known anophelines was increased to seven in Urich's (7) paper "Mosquitoes of Trinidad" in 1913. He says: "*A. tarsimaculata* is the commonest anopheline occurring all over Trinidad wherever favourable conditions exist, namely man and suitable breeding places near his houses. It is the principal carrier of the malaria parasite, if not the only one." Lassalle (8) increased this number to eleven in his 1913–1916 reports, and in his 1920 report (9) states that *A. albipes (aquasalis)* and *argyrotarsis (albitarsis)* convey malaria in the Colony. de Verteuil (10), in 1925, states: "The studies of Darling and others in Panama leave little doubt that *tarsimaculatus* and *albimanus* (which form about 80 to 90 per cent of the total number of anophelines in the populated parts of the Island) are here the usual carriers of benign tertian and quartan fevers. The following observations, made over a number of years, have led me to believe that the usual carriers of malignant tertian are *argyrotarsis* (*albitarsis*) and *maculipes* (*neomaculipalpus*), or both. Together they constitute about 5 to 10 per cent of all *Anopheles* and have been found in most parts of the Island." In his 1930–1934 reports (11) de Verteuil fully established the importance of *A. aquasalis*. He showed this mosquito to be the main vector of malaria in the swamp and riverine areas of the Colony and adduced excellent epidemiological evidence incriminating *A. bellator* as the main vector of malaria in the high rainfall cocoa bearing areas. This finding was eventually confirmed by the work of Rozeboom and Laird (12) in 1941. They dissected 725 mosquitoes and found three infected, two with oocysts and one with salivary gland infection and they also succeeded in infecting the species experimentally. This was the first time that a member of the subgenus *Kerteszia* had ever been implicated definitely as a vector of malaria, although various species of *Kerteszia* in other countries had likewise been suspected (13, 14).

With the coming of World War II and the establishment of American bases in the Caribbean islands, several distinguished workers in malaria visited the Colony. Foremost among these were Colonel W. H. W. Komp and Dr. Mark Boyd. To the latter was mainly due the establishment in 1941 of a fruitful period of cooperation in malaria investigation and control between the Government of Trinidad and Tobago and the Rockefeller Foundation. The report (15) of the comprehensive malaria survey of the Colony so jointly undertaken constitutes the basis of subsequent malaria investigations and its control. The report showed:

1. That about one-half of Trinidad is practically malaria free.

2. High malaria rates are widespread in northeast Trinidad, (15 of the towns here had rates ranging between 21.3% to 81.6%) and in a number of smaller and rather widely scattered coastal portions of the Island. Tobago, likewise, has high malarial rates in several population centres.

3. Thirteen species of *Anopheles* occur in Trinidad, four of which have not been previously recorded in Trinidad. Another species (*A. pseudopuntipennis*) which undoubtedly existed here previously could not be found in spite of intensive search.

4. Only two of the *Anopheles* are dangerous malaria vectors, *Anopheles aquasalis* and *Anopheles bellator*. The former is responsible for most of the malaria in the two islands, chiefly that found along the coasts. The latter breeds in the "Wildpines" (wild plants of the pineapple family or the epiphytic bromeliads) which grow in great abundance in the cocoa plantations. The spleen rate among school children in eight towns in the high rainfall cocoa zone of Trinidad ranged from 21.3% to 50%.

5. Dissections of 1,364 house-caught *Anopheles aquasalis* gave an oocyst rate of 3.3%; only one salivary gland positive was found in the series. A total of 1,263 *Anopheles bellator* dissections produced an infection rate of 0.78%; no salivary gland positives were encountered.

6. Malaria therapy for the treatment of general paresis was initiated in St. Ann's Mental Hospital. Nine Negro patients were treated with *P. falciparum* and one white patient with *P. vivax*.

7. In experimental feedings (conducted in connection with the malaria therapy) *Anopheles aquasalis, Anopheles bellator* and *Anopheles albitarsis* were found to be very susceptible to *P. falciparum*. *Anopheles oswaldoi* and *Anopheles neomaculipalpus* proved too refractory in their feeding propensities to supply sufficient data for satisfactory conclusions.

8. *Anopheles aquasalis* appears to be the only vector of malaria in Tobago.

9. The malarious parts of Trinidad may be roughly divided into two categories, the "over-head" malaria districts and the ground-water malaria areas. In only a few localities do the two malarias combine. Obviously the time honoured system of oiling ground waters must give way to new types of malaria control measures in the localities where overhead waters are responsible for the presence of the disease.

10. The urgent need for the study of the Bromeliaceae and *Anopheles bellator*.

In subsequent years, taxonomic and ecological studies on the bromeliads were carried out by C. S. Pittendrigh (16) and have yielded both practical and academic results of considerable value. Seven species of Bromeliaceae new to the local flora were discovered, and 59 species were listed as occurring in the Colony. The ecological studies have permitted a "natural habitat grouping" of the species which serve to explain the geographical distribution of the plants in Trinidad and Tobago. The peculiar structure and physiology of the plants render them susceptible to plant poisons. Owing to the arboreal habitat of the plants, they have developed funnel-shaped forms which enable them to collect and maintain reservoirs of water over long periods of time, hence one of their common names, "tank plants." Further, their leaves, particularly in their lower portions, have absorbing scales—a structure unique in the plant kingdom—which enable them to absorb this water and nutriment as well. These features provide an avenue of attack which is considerably faster and more economical than the obvious manual removal. The plants are readily killed by dilutions of plant poisons which have not the slightest effect upon the vast majority of other vegetation.

In 1948, Major R. A. Senior-White, was appointed Entomologist, Malaria Division, Trinidad and Tobago, and the preliminary studies that he has executed on the bionomics of *A. aquasalis* have been published in a large monograph "Studies of the Bionomics of *Anopheles aquasalis* Curry, 1932" (17). The discovery of daytime resting places of *A. aquasalis* and the evaluation of blood preferences of *A. aquasalis* by precipitins are among the more important observations in this report. In connection with plant preferences in outdoor resting, considerable use has been made of an unique apparatus for microclimate studies. Penman's micro-humidity apparatus depends on the very rapid changes in resistance in a pellet of a mixture of oxides, a trade secret of Standard Telephones & Cables, Limited.

The pellet is placed in a glass tube about the size of a clinical thermometer, with wires leading to a variable resistance bridge. A calibration curve, (individual to each tube, which is termed a "thermistor") serves to turn resistance into temperature. Two closely mounted thermistors, one gauze covered, serve as dry and wet bulb thermometers. Measurements can be made in a ¾ inch diameter area. The apparatus, as at present designed, is untrustworthy in light of >500 f.c. or a strong wind. Only 7½% of *aquasalis* resting is at >500 f.c., and there is little air movement in the bottom foot of vegetation. The apparatus works on standard torch dry cells, and is easily portable. It is not on the market and the only two instruments in existence have been built by technicians from odd parts purchased separately. A modification of the thermistor design so that the dry and wet bulbs do not interfere with one another by radiation or wet bulb moisture is being explored.

In spite of the publication of the large monograph referred to above and three subsequent papers in press, our knowledge of *A. aquasalis* contains notable lacunae. In particular, we do not know with any exactitude its optimum flight range either in dispersal or directly to blood. It is so difficult to mass breed and so delicate when tube caught that significant results may be obtained only with the aid of P^{32} in the larval food and a Geiger counter. The survival of eggs on mud free of surface water was first brought to attention during the attempted malaria eradication program in Tobago and is now under laboratory investigation. Predation still requires detailed study, and natural oviposition of this mosquito is yet to be seen.

In addition to this program of work with *A. aquasalis,* work is proceeding with regards to *A. albitarsis, A. neomaculipalpus* and *A. eiseni.* This latter mosquito breeds in hillside streams and the adults are found resting between the buttress roots of forest trees. It does not rest on grass and shrubs nor among bamboo stools nor dark holes in the bottom of cocoa bushes. It has been taken on rocks, in shade and in stronger light among moss and rocks. It seems to remain close to its breeding water and bites man readily.

Anopheles neomaculipalpus may be a vector of secondary importance in the transmission of malaria and considerable study will have to be devoted to this mosquito as well as to *Anopheles albitarsis* of which little is known of the larval ecology. This latter mosquito is virtually absent from December to June in areas where it is taken in extremely high densities during the rainy season. How it passes the dry season is not known and it is a likely suspect of the low malaria endemicity of the inland plain.

Very little is really known of the widely differing biology of the two common local *Kerteszia.* They attack throughout the day and at least during the early part of the night. Their dawn behaviour is unknown. They are stated hardly to enter houses at all but further study is required to confirm this. They have been recovered in open verandahs. A more exhaustive study of the bromeliad species preferences and productivity is being made. The ecoclimate of the forest where both *Kerteszia* breed needs detailed studies and already preliminary studies into the growth and regeneration of bromeliads have been undertaken. At the moment, the extent to which winds and birds play a part in dispersal and growth is under study. The replacement of copper sulphate sprays by other herbicides of the 2,4,D type opens new avenues of control. Their application presents many local difficulties calling for much experimentation.

Considerable work has also been done in evaluating the efficacy of residual sprays as well as some of the new insecticides against our local anophelines. Special attention is being devoted to the innumerable types of wall surfaces found in the Colony whose population consists of representatives of every racial group of mankind.

MALARIA CONTROL

Prior to the recognition of the role of the anopheline mosquito in the transmission of malaria, the usual time-honoured practice of dealing with malaria as a disease due to the emanation of noxious gases from the swamps was rigidly adhered to in Trinidad. We find the same Dr. Alexander Williams, to whom reference has been previously made, advising the Spanish Governor in 1795 to change the place of anchorage of their men-of-war to some other site where the men would breathe a more salubrious and purer air. Many of the early settlers in the Colony forsook the coastal regions for the densely wooded valleys of the Northern Range thereby contributing immensely to the early establishment of economic crops in these valleys. After 1900, the teachings of Gorgas and the lessons of the Panama Canal were put to good practical use by Dickson and Lassalle, two men who were keenly alive to the immense po[illegible]ies of improving malaria control and [illegible]se contributions were made at a tim[illegible] [illegible]hen few men were able to envision at i[illegible] true worth the value of such a work.

The establishment of the sugar estates during the early years of the 19th century contributed greatly, through th[illegible] adoption of a wise policy of drainage, to the comparative freedom from malaria of those areas in the Central Plain where one would normally have found much malaria. Owing to the clayey nature of the soil, deep and well-graded drainage lines had to be laid down and the drainage systems then established stand out, even today, as models for all others. In the cocoa bearing belt, from 1890 to 1914, large tracts of forests were cut down and gradually planted with cocoa.

It is unfortunate that the cultivation of cocoa was attended with the planting of shade trees of the *Erythrina* group, species particularly susceptible to the harboring of bromeliads. As a result of the mosquito infestation of these cocoa estates, it became a *sine qua non* that all houses were efficiently and effectively screened from the very earliest days.

With the discovery of oil in Trinidad, the operating companies immediately realised the benefits of protecting their employees from malaria. It is largely due to their thorough and progressive antimalarial policy despite limited knowledge, that in addition to the usual drainage and anti-larval measures, the screening of bungalows and improvement in medical assistance as well as in housing and living conditions of the labouring classes were rapidly established in their operational areas.

An important advancement in malaria control was the early construction of low tide culverts (18) to deal with the coastal drainage of the innumerable streams with which the Colony is favoured. Though these low tide culverts were, by and large, a failure, they pointed the way to the development of the self-clearing seaheads for low drainage through surf (19). A self-clearing outfall at low tide through sand bars ... up by surf action is necessary in order ... keep open the mouths of many rivers, wh... have only a small dry season discharge, ... after the rains have ceased.

No attempt was made prior to 1941 to control bromeliad malaria largely due to the complexities of the problem and inadequate knowledge of the anopheline vector in the cocoa bearing high rainfall districts.

The present malaria control program of the Colony embraces the usual features of clearing, drainage and larviciding together with the execution of capital works such as the construction of self-clearing seaheads and the reclamation of seepage and swampy areas. In some instances, automatic siphon flushes have been erected and where the location has been suitably and carefully chosen, excellent results have been obtained.

In *Anopheles bellator* country, considerable progress has been made in the control of bromeliad malaria. Advantage has been taken of the peculiar physiology of the plants involved. Many technical and operational difficulties had to be overcome before a suitable machine could be got together to deliver a lethal but dilute solution of copper sulphate to the bromeliads.

The equipment used consists of a pump driven by a six-cylinder gasoline engine and capable of pumping the solution at pressures up to 2000 lbs. per square inch. The solution is prepared in two tanks attached to the pump and continuously agitated by paddles. An auxiliary pump fills the tanks with water from a pond or stream near which the equipment is located, and the required quantity of copper sulphate is added to make a solution containing ½% copper sulphate. The tanks are used alternately so that while solution is being pumped out of one, the other is being filled and mixed. The solution is taken into the field by 1″ reinforced high pressure rubber hose and is discharged in a solid stream through a 5/16″ nozzle at a pressure of 300–350 lb. so that plants growing 60–80 feet above the ground could be sprayed. The power of the pump makes it possible to spray trees as far as one mile from the equipment, which must be located near an adequate water supply since there is a nozzle discharge rate of 35 gallons per minute. This equipment is mounted on a truck chassis and has been in use in the cocoa areas of east central Trinidad since 1945. Over 4,000 acres of cocoa lands have already been treated and in the Sangre Grande district, where the work was first started, malaria (spleen) rates have fallen from 30% to 5% due to this method of control alone.

A residual DDT house spraying program has been executed since 1945 and this year, the program will be extended to every one of the estimated 160,000 houses in the Colony.

Tobago, the island ward of the Colony, has been the subject of a special malaria eradication project jointly sponsored by the Rockefeller Foundation and the Government of Trinidad and Tobago. The island itself has no very large swamps and *A. aquasalis* is the only vector of malaria. Seaheads and low tide culverts, swamp reclamation and the diversion of main drainage lines together with the usual temporary measures of control and a bi-annual application of DDT and Gammexane to all houses have been executed.

The net result of the intensive program of malaria control executed in the Colony has yielded most satisfactory results. In Tobago, the spleen rate which was nearly 20% before the commencement of the control program fell to less than 1% in 1951 and this reduction has been maintained in subsequent years. Tobago has already lost its old reputation as being one of the most malarious islands of the West Indies and is becoming more and more the holiday resort not only of Trinidad but of an increasingly large number of people from the United States of America and Great Britain.

In Trinidad, comparable results have been achieved particularly in the areas surrounding Port of Spain where the malaria rates were in the vicinity of 35% to 40%. Recent surveys have indicated that they are now less than 3%. Likewise in the north eastern promontory of the island where the highest rates were found ranging from 60% to 83%, malaria rates have been held down for the last five years to less than 5%.

Given the continuing support of an enlightened Government and an intelligent interest in malaria control, it is not too optimistic to hope that by a process of attrition, and without the expenditure of sums beyond the economy of the island, malaria may yet disappear completely from the Colony within the next decade.

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THE PEST CONTROL OPERATOR'S PLACE IN MOSQUITO CONTROL

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Before being specific regarding the part that the pest control operator might have in the field of actual mosquito control service work, it seems to me that there should briefly be submitted two general observations.

In the first place, very little basic research work can be expected to be done by the PCO. Essentially the PCO depends upon governmental research personnel as well as manufacturers of chemicals and equipment to provide the answers regarding formulations and acceptable techniques of application for the elimination and control of mosquitoes.

Secondly, there is the common denomi-