

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.

YELLOW FEVER IN TRINIDAD—A BRIEF REVIEW

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Trinidad is the senior partner in the British Administrative set-up known as the Crown Colony of Trinidad and Tobago. The island is situated between $10^{\circ} 3'$ and $10^{\circ} 44'$ north latitude and $60^{\circ} 55'$ and $61^{\circ} 44'$ west longitude and has an area of 1863 square miles. Its greatest length is 50 miles from north to south and greatest breadth 32 miles from east to west. It is roughly rectangular in shape with large narrow promontories on the northwest and southwest and lies, at its southwestern end, but seven miles from the Venezuelan coast. Its capital is Port of Spain, with nearly 120,000 people out of a total population of roughly 670,000 persons for the entire colony.

Geologically the island compares with the structure of the adjacent South American coast and consists almost entirely of sedimentary rocks. In ancient times the island probably formed part of the delta of

the Orinoco and in the northern portion of the island there is considerable faunal and floral affinity with the fauna and flora of the Orinoco. According to R. C. Marshall (1) the island can be divided into five main belts and is considerably wooded, particularly in the northern range of mountains which possesses two peaks of over 3,000 ft. each.

The island has a tropical climate and apart from a well defined dry and wet season shows little climatic diversity. The rainfall ranges from between 50" to 60" in the flat coastal lands to over 120" in the hills.

The forests in many localities abound normally with monkeys, there being two species, *Alouatta seniculus insulanus* Elliott or howler monkeys and *Cebus apella* Linn, the capuchin or white faced monkey.

Yellow fever was long considered absent from the island, the last reported

cases having occurred in 1914 in a rural area and the last urban outbreak in Port of Spain in 1907.

Scott (2) lists the outbreaks in the West Indies from the year 1493, five years before the discovery of Trinidad by Columbus, the first outbreak in Trinidad being given as the year 1796-97. It is more than likely there was yellow fever prior to this as the neighbouring islands of Barbados and Grenada have histories of yellow fever as far back as 1646. Since 1796 outbreaks occurred in 1818, (1820 in Tobago with an 80 percent mortality), 1828 (13 percent mortality), 1838, 1858, 1869, 1889, 1891, 1894, 1906-07, 1910-11 and 1913-14.

The Annual Reports of the Surgeon General (3) for the years 1906-07, 1907-08, 1908-09, 1910-11, 1913-14 give full details on the occurrence of yellow fever during these periods. In the outbreaks of 1906-07 there were 24 cases with 11 deaths, it being reported that the later cases were generally of milder type (3). Of the first five cases, four proved fatal and were persons who had lived less than 2 years in the West Indies—a most significant feature, which he analyzes in his reports of the next year. The following table is taken from this report.

Total Cases	Sex		Av. Age		Race			Deaths		Recov.		Death Rates	Percent D.R.	
	M	F	M	F	Wh.	Col.	Blk.	M	F	M	F	M	F	
	47	32	15	25.9	23.46	40	5	2	18	10	14	5	59.57	56.2

(Only 10 of the cases were natives of the West Indies)

In an earlier report the Surgeon General comments on the proximity of Venezuela and the fact that there was no obligation on the Venezuelan authorities to certify this infectious disease. Special powers were obtained in March and April 1907 and amended in January 1908 for the purposes of improving sanitary conditions and destroying mosquitoes, and in the light of present situation his bitter criticism which states: "In this connection the importance of individual efforts in co-operation with Sanitary Authorities can scarcely be over-estimated and it is sur-

prising, and a matter for regret that persistent practical demonstration and instruction by the Sanitary Staff appear to arouse so little personal interest and sustained effort towards the protection of the individual and the community from the extension of the disease," was equally applicable in 1954.

Only three cases occurred in 1908-09 (2 deaths). All were males and resided from 5-11 months in Trinidad, one was English, one German and one American. The following year there were two cases reported and both died, both young males 18 years of age, and both born in Madeira. In the light of our present knowledge one wonders at this stage what the real morbidity of yellow fever was during these years in question.

Finally there was an outbreak at Brighton in 1913 (4). Ten known cases occurred and three died. Of these ten cases, only one, a planter, had spent more than two consecutive years in Trinidad and except for him all were Americans.

It is interesting to note that Balfour (5) refers to dead monkeys in connection with the 1913-1914 outbreak mentioned above and speculates upon their connection with the disease. He was the second person to

refer to dead monkeys in Trinidad in connection with yellow fever outbreaks, Charles Kingsley (1871) in his book "At last, A Christmas in the West Indies" being the first.

THE PRESENT OUTBREAK. During 1953, the Trinidad Regional Virus Laboratory took samples of blood from the inhabitants of the Manzanilla, Biche, and Sangre Grande areas lying at the eastern foothills of the Northern range. A number of the blood samples neutralised yellow fever virus, and in view of the fact that the ages of the individuals varied from 15 years to

40 years it would appear that yellow fever (undiagnosed and unrecognized) had been present in Trinidad since the last outbreak in 1913 (4).

On April 22nd 1954 an agriculturist of mixed blood living in Cumaca, a village nestling among the foothills of the north-eastern end of the northern range, was admitted to the hospital at Arima. A sample of blood was obtained the same day by the Virus Laboratory. Pending the result the patient was treated as a case of malaria. His illness was mild and he made an uneventful recovery. His blood neutralised yellow fever virus. This was the first case of undoubted yellow fever since 1914 and the serological findings are discussed by Anderson, Spence and Downs (6).

A period of three months elapsed without any further cases coming to light, but during this time there were reports from hunters that the bodies of dead monkeys were being discovered in the forests. Then between 27 July 1954 and 6 October 1954, fourteen additional cases were reported from various parts of the Colony. Of the total of 15 cases, 4 died. With one exception all cases occurred in areas adjacent to forest or in people who had recently been in the forest. This exception was a patient—a young woman—who denied having ever left Port of Spain for some time, and under these circumstances the probability of *Aedes aegypti* being involved was considered.

Yellow fever virus was isolated on several occasions by the staff of the Trinidad Regional Virus Laboratory from *Haemagogus* mosquitoes collected in the forest of Melajo and Charuma. *Haemagogus* mosquitoes have also been collected in wooded suburbs of Port of Spain.

Aedes aegypti were extremely prevalent and in most areas in the island the indices were very high. In 1948, in the course of routine mosquito investigations, the staff of the Malaria Division, Health Department, Government of Trinidad and Tobago, had been alarmed at the high densities of *Aedes aegypti* found and instituted an island wide compilation of *aegypti* in-

dices. As a result it was recommended that an *Aedes aegypti* eradication program be immediately embarked upon, but like so many other public measures that do not strike with immediate and spectacular urgency, the matter was shelved. In the light of the subsequent demonstration of resistance in *Aedes aegypti* to DDT, it is interesting to speculate what would have happened to this mosquito if eradication measures based on DDT had been executed 6 years before.

MEASURES ADOPTED—A. THE EARLY YEARS. Prior to the discovery of the role of the mosquito in yellow fever transmission, cases of the disease were treated, or rather neglected, and frequently shunned either in hospital or at home. In severe epidemics, large sections of the population fled and but too often the dead were left to rot for several days.

In the 1906–1907 epidemic, on diagnosis of a case, the patient was isolated, usually in hospital, and screened. His house and adjoining premises were fumigated and the neighbours kept under surveillance. In addition, the staff of Sanitary Inspectors was augmented and an attempt made at better inspection and cleaning of yards.

In 1907 and 1908 special powers were obtained by the Health Department. These powers were aimed to improve sanitary condition and called for the extensive destruction of mosquitoes. Prosecution of offenders was rigorously undertaken and in 1911, 473 informations were laid for breach of Mosquito Regulations and BWI \$555.72 was levied in fines (5).

In 1912 there were 129 prosecutions with convictions obtained in almost all cases and the fines realised \$151.08 (6).

In the Brighton outbreak of 1914 the differentiation between jungle and urban yellow fever was appreciated and in addition to re-screening and fumigating the Company houses and oiling all stagnant water, it was suggested:

(1) To allow no non-immune to go to the forest for a period of 5 weeks since the last case;

(2) To cut down and clear the forest 100 ft. on each side of the main road through the oil field (5 miles);

(3) To clear the forest for a radius of 900 ft. from the center of each well or field;

(4) To burn brush and drain the exposed area;

(5) To build screened barracks for native employees.

B—1948-1954. Reference has been made to the proposals put forward in 1948-1950 for the eradication of *Aedes aegypti*. Though this scheme was rejected, a token vote was eventually provided to control the high indices found in the island survey executed between 11th September and 4th December, 1950.

The area selected for this token project was the most thickly populated area of the island with Port of Spain as the center. All water containers both outside and inside premises were treated with a suspension of 25% wettable powder DDT at the rate of 1 drop per gallon of water. We were assured by experts that this treatment would kill all *Aedes* larvae and have a residual action for a considerable period of time and that two or three cycles of such treatments would eradicate the mosquito. Immediately on the commencement of the program, the field staff led by Dr. F. R. S. Kellett and Sanitary Inspector Carlton Gilkes, found that this was not so. Larvae in barrels and drums refused to exhibit total mortality and in those few cases in which a container had had all its larvae killed, fresh breeding was found in 12-14 days. Larvae that had been exposed in the field to a sufficient dosage of DDT were successfully bred out into adults in the laboratory and as a consequence, much time was consumed in a thorough review of techniques both in the laboratory and in the field. Dosage of containers was considerably increased but even when carried to the maximum safe limits, total mortality was absent. Advisors and experts came and went. No serious fault could be found with the techniques and the matter had to be dropped owing to lack of funds.

1954-1955. The finding of the Trinidad Regional Virus Laboratory regarding the neutralising of yellow fever virus by the serum of certain people in the Biche, Manzaniilla, Sangre Grande area was communicated to us at the end of 1953. Two capture stations were set up by us in this area and bi-weekly human bait captures of mosquitoes made. On one occasion only was *H. spegazzinii* captured, the prevalent species taken being *Mansonia mansonia*, *M. titillans*, *An. oswaldoi* and many *sabethines*.

The report in April 1954 of undoubted cases of yellow fever galvanised the whole island into activity and the following steps were taken:

1. An island-wide project to inoculate all persons with yellow fever vaccine;
2. An increase in the personnel to carry out island-wide DDT residual spraying;
3. The immediate formation of anti-larval teams to cover the island;
4. The assistance of PASH to supply advisers, DDT and vaccine;
5. Legislation for the compulsory treatment and spraying of premises.

By 23rd September, the antilarval teams were at work—a motley collection of spray cans were pressed into use, but by the end of October, all were equipped with Dronwall P.3 spray cans.

In spite of our forebodings and previous experience that only concentrated and short frequent cycles in anti-larval treatment could achieve results, we were assured that a single island-wide treatment of 75 percent wettable powder DDT at 1 drop per gallon of water would achieve eradication.

Eradication by these means was never had in any single area. There was a diminution in the *Aedes* indices beyond the critical densities and this diminution coupled with vaccination and residual DDT house spraying of every house in the colony were without doubt the main factors in preventing a severe epidemic of yellow fever. The importance of the early discovery of the disease together with the

assiduous watch kept over any new case of fever reported by the Trinidad Regional Virus Laboratory cannot be over-estimated.

DDT suspensions were succeeded by or combined with DDT emulsions. Dosages were stepped up and every flaw, no matter how minor, eliminated in our techniques. Nevertheless, total mortality could not be achieved and fresh breeding regularly appeared in treated containers.

Laboratory investigations proved what was suspected, namely, that resistance to DDT had occurred in *Aedes aegypti* thus shattering the position of this mosquito as the classic susceptible to the chemical. Colonies of local strain of *Aedes aegypti* were established at a field insectary and at the laboratory and DDT in up to 200 parts per million failed to kill larvae in 48 hours. This has been reported upon in our Annual Report for 1954.

In June 1955 we were requested by Dr. Fay, Ent. U.S.P.H.S., Savannah, Georgia, for a supply of *Aedes aegypti* eggs for the purpose of testing the mosquito for resistance to DDT and other insecticides. We have had no official report yet but a personal communication from a member of the Trinidad Regional Virus Laboratory informed us that the larvae and adults hatched from the eggs supplied were highly resistant to DDT.

Our laboratory testing of larvae showed that there was practically no resistance to BHC and dieldrin and as a result, the

larviciding teams are now using BHC in the form of dispersible powder P.520 and emulsion concentrate containing 20 per cent gamma BHC, and the results to date with this insecticide have been good. If resistance to this insecticide does not develop, *Aedes aegypti* will be eradicated from Trinidad and Tobago.

SUMMARY. A brief review of the occurrence of yellow fever in Trinidad is presented with special reference to the 1954 outbreak and the measures adopted then to control *Aedes aegypti* which had developed resistance to DDT formulations.

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