extending for a distance of four hundred metres around that perimeter ". Such an operation at Entebbe would involve a great expenditure of effort against mosquitos in all probability of no importance at all in the transmission of yellow fever. It might in any case be only in the nature of a lip service to the Regulations, as the breeding-places are probably so extensive that the treatment of the area within 400 metres' radius of the airport, even though close to it, might have but little effect on the numbers of *Taeniorhynchus* present there.

On the other hand, action is open to the health administration, under Article 70. 2 of the Regulations, to apply for the notification of the airport as outside the yellow fever endemic zone if " the *Aëdes aegypti* index has continuously remained for a period of one year below one per cent." Although in Entebbe, where *A. simpsoni* appears not to bite man, this course would seem to be a safe one, it may well be dangerous in other parts of Africa.

The logical answer to a problem of this sort would appear to be the introduction of a regulation which would allow the neglect, as far as yellow fever is concerned, of mosquito species to which suspicion has not attached in the field—thus allowing the laboratory transmission of yellow fever virus by *T. (M.) africanus* and some other species to be ignored—and the extension of Article 70 to include, besides *A. aegypti*, at least *A. simpsoni* and *A. africanus* and perhaps other species of the subgenus *Stegomyia* as well.

THE YELLOW FEVER SITUATION IN THE BECHUANALAND PROTECTORATE *

The Bechuanaland Protectorate is 275,000 square miles (approximately 712,000 km²) in extent with a population of 295,000 (i.e., about 1 per square mile or 2.4 per km²), of which only 2,200 are Europeans. The distribution of the population is very uneven, most of the people living in the eastern and north-western parts of the territory. The southern, central, and western parts constitute the Kalahari Desert, which is not really desert in the generally accepted sense of the word, but consists of vast expanses of undulating sand belts with outcrops of limestone here and there. Large areas are wooded, like park-lands, studded with camel-thorn and other indigenous trees. The grasses are often excellent in this area. The climate is mainly subtropical, but the average rainfall is only 20 inches (approximately 50 cm).

In June and July 1949, approximately 450 blood specimens were collected from the inhabitants of the villages bordering on the Okavango swamps in

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Ngamiland, north-west Bechuanaland, and in the Chobe district, north-east Bechuanaland.

At the same time approximately 50 blood specimens were collected from monkeys shot in trees in the neighbourhood of the swamps.

The sera separated from these blood specimens were submitted to the yellow fever mouse-protection test at the South African Institute for Medical Research, Johannesburg, using the 17 D strain of yellow fever virus for the challenge. The following criteria of protectiveness were used in interpreting the results :

positive = 6 or more survived of 8 mice inoculated
negative = 2 or less survived of 8 mice inoculated
inconclusive = 3-5 survived of 8 mice inoculated

Table I gives a summary of the results.

TABLE I. RESULTS OF YELLOW FEVER MOUSE-PROTECTION TESTS ON HUMAN AND MONKEY SERA COLLECTED IN BECHUANALAND PROTECTORATE

Village	Number of specimens			
	positive	inconclusive	negative	total
	Human Sera			
Tsau	1	3	51	55
Nokaneng	0	3	52	55
Shakawe	2	8	71	81
Seronga	0	7	80	87
Maun	1	1	56	58
Kachikau	0	3	41	44
Kasane	1	6	44	51
Total	5	31	395	431
Percentage of total	1.1	7	91.9	100
	Monkey Sera			
Ikwaga, Seronga, and Nokaneng area	0	1	39	40
Kasane	0	0	3	3
Serondellas	0	0	3	3
Kazangula	0	0	1	1
Total	0	1	46	47

These results were similar to those obtained in a previous survey undertaken by Dr. Smithburn on blood specimens collected in 1945. Since that time, therefore, there has been no increase in the proportion of blood specimens giving positive protection tests : indeed, the proportion of positive sera to negative has declined somewhat.

From these results it was concluded that, in the area tested, conditions were not building up to an outbreak of yellow fever such as occurred in the Nuba Mountain region of the Sudan. There was, however, some evidence of the occurrence of cases of infection with the virus of yellow fever in the area of the Okavango swamps. However, the number of such cases was very small indeed, being approximately 1% of all the individuals whose blood was tested. In addition, all the positive cases were found in nomadic tribes whose movements are extensive and go beyond the borders of the Bechuanaland Protectorate.

There was also no evidence of the infection of the monkey population of this area with the virus of yellow fever.

One was therefore inclined to the opinion that yellow fever is not endemic in this area and that, possibly, the small number of human blood-specimens giving positive mouse-protection tests was from individuals who owe their immunity either to a transient introduction of the infection or to a visit to an infected area outside the territory.

Meanwhile, in the WHO *Weekly Epidemiological Record* No. 183 of 28 June 1950 that part of the Bechuanaland Protectorate lying between the 23° and 25° E. meridians of longitude down to the 21° S. parallel of latitude was incorporated in the African Endemic Yellow Fever Area, but this was repealed in the *Weekly Epidemiological Record* No. 207 of 13 December 1950.

In 1951, 317 specimens of human serum were collected from persons in the Francistown-Maun area, particularly from the villages in the overnight stopping places of the Witwatersrand Native Labour Association convoys, and from Francistown itself, and submitted to the South African Institute for Medical Research, Johannesburg, for mouse-protection tests. All these sera gave negative results with the exception of two positive and one inconclusive (5/6 and 4/8 protection). One of the positives had lived most of his life in Barotseland but had died of pulmonary tuberculosis in Bechuanaland before his movements could be more fully explored. Available information was to the effect that he had lived in Bechuanaland about 30 miles north of Francistown during the " last few years " only. The other positive and the inconclusive had lived in the Bechuanaland Protectorate all their lives, the former mainly in the Nata area but nomadically, and the latter north of Francistown.

At the same time 50 blood specimens from schoolchildren in Francistown were also subjected to mouse-protection tests, all with negative results. It is intended to carry out further tests on the same group of children at yearly intervals to determine whether any immunity is developing over the years. A further batch from the same schoolchildren was sent in June 1953, but the results are not yet available.

In 1946, Dr. Botha De Meillon carried out a summer survey of the mosquito fauna in the Ngamiland, Chobe, and Francistown areas. This

was followed by a winter survey carried out in 1949, and by a short survey in the Francistown area in January 1952.

During the 1946 summer survey the following proved and suspected vectors of yellow fever were found: *Aëdes (Stegomyia) aegypti*, *Aëdes (S.) simpsoni*, *Aëdes (S.) vittatus*, *Aëdes (S.) metallicus*, *Aëdes (S.) luteocephalus*, *Culex (Culex) fatigans*, *Taeniorhynchus (Mansonioides) africanus*, and *Taeniorhynchus (M.) uniformis*. The result of the intracerebral inoculation of wild-caught mosquitos into mice was negative. Mouse-protection tests done on sera collected from monkeys at this time also proved negative. At ground level, the predominant mosquitos both in heavy forest fringing the swamps and in open country near the swamps were *Taeniorhynchus (M.) africanus* and *T. (M.) uniformis*. The predominant " canopy " mosquito was found to be *Aëdes (S.) luteocephalus*.

Kasane in the Chobe area was the only place where the classical set-up of jungle yellow fever was evident to any degree. Elsewhere along the swamps—Maun, Gomare, Mohembo—hardly any *Stegomyia* were encountered. The predominant mosquito in the swamps is *Mansonioides*. These are omnivorous and bite both during the day and certain hours of the night.

During the winter survey it was confirmed that in the Ngamiland and Chobe areas there is a complete absence of species of the subgenus *Stegomyia*. The results of the summer and winter surveys make it clear that there must be a break of several months in the possible transmission season. This is to be expected since northern Bechuanaland is an area of summer rainfall and winter drought. A few *Stegomyia* may survive the dry winter as adults. If they do so they must be so rare as not to affect the position in any way. It is quite obvious that these *Stegomyia* survive in the dry winter in the egg stage. The eggs lie dormant in breeding places—tree holes, etc.—until the summer rains fall, when they hatch.

The mosquitos which are present in both summer and winter consist almost entirely of the zoophilic anophelines *A. coustani* series, *A. distinctus*, *A. squamosus*, and a few *Culicinae* and *Mansonioides*. Among the culicines, *Culex (C.) univittatus* bites man readily; so do *T. (M.) africanus* and *T. (M.) uniformis*, whose numbers are greatly reduced in winter. It was thought that if virus is being transmitted during the dry season, then it must be carried by these mosquitos. The two species of *Mansonioides* are known from laboratory experiments to be capable of harbouring virus, but they have not been found infected in nature. It seems unlikely that species of mosquito found in northern Bechuanaland during winter can act as vectors, though one cannot, of course, be dogmatic.

Dr. De Meillon concluded from this survey that yellow fever virus is probably not actively transmitted during the long, dry, winter spell, and that conditions for active transmission are possible only for a relatively short period during the rainy season. This, he thought, seemed to preclude the possibility that yellow fever is endemic in Ngamiland, and some other

explanation should be found for the presence of the few immunes among the indigenous population. He suggested that active virus infiltrated with migrant labour into Ngamiland from some endemic focus in the north, and that the short transmission season accounted for the few immunes to be found along the edges of the swamps.

Meanwhile, the Transvaal Chamber of Mines desired to transport mine recruits by air from Lilongwe in Nyasaland and Mohembo (Shakawe) in the north-west of the Bechuanaland Protectorate to Francistown in north-east Bechuanaland, whence they would go by rail to the Rand. The 1952 survey in Francistown already referred to had confirmed the presence there of *Aëdes (S.) aegypti*, *Aëdes (S.) metallicus*, *Aëdes (S.) unilineatus*, and *Aëdes (S.) pseudonigeria*, of which at least the first two mentioned are yellow fever vectors.

Aëdes (S.) aegypti in Francistown appeared to be a domestic species, the breeding-places being collections of water in tanks, tins, bottles, drums, roof gutters, old tyres, etc. It also occurs in water collecting in rot-holes in trees. It was not possible to make an *Aëdes* index, but in any event it was felt that nothing short of total control should be aimed at.

Larvae and pupae of *Aëdes (S.) metallicus* were found in tree-holes and vases at a cemetery, while adults were common in all scrub country around the town and the aerodrome. The adult is silent in flight and appears to prefer the lower extremities for feeding purposes. It is not a mosquito that is readily noticed.

It was considered that *Aëdes (S.) metallicus*, a proved vector, is of some considerable importance to Francistown and its surroundings. Its ability to breed in the minute collections of water that collect in thorn and mopani trees and the resistance to desiccation of the eggs makes it difficult to control. The adults are not domestic and so cannot be controlled with residual insecticides. The fact that it is common and readily attacks man during the day greatly enhances its opportunities for acquiring infection and passing it on.

The *Aëdes (S.) unilineatus* and *pseudonigeria* found are not proved carriers, but must be regarded with suspicion. It is thought that control of *metallicus* will eliminate *pseudonigeria* and *unileatus*.

Permission was then given to the Chamber of Mines to fly recruits to Francistown from Mohembo (Shakawe) in the Bechuanaland Protectorate and from Lilongwe to Francistown subject to the following conditions: [1]

(*a*) All recruits would be inoculated against yellow fever and kept under surveillance at Lilongwe and Mohembo for 8 days before being flown to Francistown.

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[1] It should be added that the recruits flown from Nyasaland were collected from Tanganyika and Portuguese East Africa and not from Nyasaland itself.

(*b*) The Witwatersrand Native Labour Association's medical officers were recognized for the purpose of giving yellow fever inoculations, and both the Bechuanaland Protectorate and the Union of South Africa recognized the unofficial yellow fever certificates issued by the Medical Officers of the Witwatersrand Native Labour Association.

(*c*) The aerodrome at Shakawe and Francistown would have a 400-metre zone free from habitation round their periphery in accordance with the International Sanitary Regulations.[2]

(*d*) Adequate insecticidal spraying of all aircraft would be carried out under European supervision.

(*e*) The movements of labourers arriving at Francistown by air would be strictly controlled. The aerodrome itself is quite safe and labourers would be transferred from there to the Witwatersrand Native Labour Association depot at Francistown with the minimum of delay after residual spraying of the aircraft and without being allowed access to the bush, which is inhabited by the day-biting vector *Aëdes (S.) metallicus*.

Meanwhile, more detailed legislation for the control of mosquitos was drawn up and submitted to the Government for promulgation. It is expected that this will be done shortly.

The following figures provide some indication of the working of the air transport scheme from its initiation on 23 June 1952 to 31 March 1953 :

Flights

Francistown to Nyasaland and return	243
Francistown to Mohembo and return	51

	Nyasaland	*Mohembo*
Recruits carried by air	7,394	2,239
Repatriates carried by air	6,082	1,911

Air transport has proved a great success and is favoured by recruits and repatriates.

* * *

The Administration of the Bechuanaland Protectorate is indebted to Dr. J. H. S. Gear and Dr. B. De Meillon, of the South African Institute for Medical Research, for carrying out the mouse-protection tests and the mosquito surveys.

[2] *Wld Hlth Org. techn. Rep. Ser.* 1951, **41**