

ENDEMIC YELLOW FEVER IN PANAMA AND NEIGHBORING AREAS

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My service on the Isthmus of Panama began December 9, 1909, as pathologist in the Board of Health Laboratory at Ancon, C. Z. So much publicity had been given this region for many years that it seemed likely that yellow fever and plague would crowd out most of the other causes of death. Imagine my surprise to find that malaria, dysentery, tuberculosis and pneumonia were the high ranking causes of death. No cases of yellow fever developed in the Canal Zone or in the terminal cities during my service from 1909 to 1922. However, rare cases arrived at the quarantine stations and sometimes these were transferred to Ancon Hospital (now Gorgas Hospital) for better hospital care and observation. Most of those cases came from the west coast of South America. It is only in fairly recent years that laboratory methods have been developed that help in establishing a diagnosis of yellow fever. There is no doubt that many ambulatory cases escaped the records. The mouse protection test has been a great advance in identifying yellow fever and the viscerotomy service has made it possible to forward liver specimens from fatal cases that occur in remote places where no doctor and no pathologist is in attendance.

From 1929 to 1931 the Gorgas Memorial Laboratory collected blood specimens from a number of adult foreign whites and others who lived and worked in the Darien province of Panama. These specimens were forwarded to the Rockefeller Foundation for protection tests. None of the adult foreign whites were positive but one 9 year old and one 16 year old native child (negroid race) gave positive tests and three others gave doubtful tests.

During the years 1935-1936 Dr. Carl M. Johnson of our staff was sent to Darien to cover several settlements and some Indian locations. The idea was to draw enough blood for a Wassermann test and a laboratory survey of Chagas disease and yellow fever. Johnson sent about 270 human blood specimens to the Rockefeller laboratory in New York, and seven of these gave a positive protection test including two children under 13 years of age. Dr. Johnson then repeated these surveys on 6 Chagres River villages (midbasin). None of these gave a positive response. No mouse protection tests were made on wild life.

There had been no indication of an epidemic in the province of Darien due to yellow fever, but from 1929 to 1937 there was a serious epidemic of smallpox in the Membrillo tribe of Indians which killed most of the tribe. The Rio Pirri tribe was almost wiped out by tuberculosis from 1929 to 1937. The tribes in the upper half of the Tucuti river had a serious influenza outbreak with a high death rate. I mention these things because word does reach the capital when things like this happen. However, yellow fever could easily escape notice if only sporadic cases appeared. There is an important interchange of people between the Atrata valley in Colombia and the Tuira valley in Panama. When the sugar mills are in operation in Colombia, there is but little labor migration,

but when the mills close, laborers move into Darien fruit, oil and lumber locations. In addition to this movement of labor, there is an average of about 20 people a month without papers who evade the law and cross the boundary, finally reaching Panama in small coastwise boats, and the same in true on the Atlantic coast.

During the months of November and December, 1948, five deaths occurred after one or two days of hospitalization in Santo Tomas Hospital, Panama City, from an acute febrile disease. No liver specimen was preserved from the first fatal case but after the fifth death it became evident that these cases strongly suggested yellow fever and on January 14, 1949, Drs. Elton and Herrera diagnosed yellow fever from the liver lesions found in two cases that died in December. These liver preparations were later brought to our laboratory for study and I agreed with their diagnosis. The delay in suspecting yellow fever was understandable because so many years had passed since there was any evidence of the occurrence of the disease in any part of the Republic. Furthermore, natives of Panama have always considered themselves highly resistant to the disease. Most of the doctors in charge of these cases had never had an opportunity to see yellow fever.

It is well to call attention to the fact that during World War II, there was a considerable development of secondary roads by the U.S. Army outposts considered necessary for the defence of the Panama Canal which resulted in some shift of rural population from such areas as the Azuero peninsula west of the Canal to formerly uninhabited and forested areas east of Panama City. Primary forest was cut, the land burned and cleared and family groups and small settlements became established. The felling of timber and the burning that followed exposed these people to mosquitoes of the forest canopy. A relatively small number came down with yellow fever and they were brought out to the highway for transportation to the hospital. Fortunately, all the highway settlements had been sprayed with 5% DDT in kerosene as part of the anti-malaria campaign which incidentally wiped out *Aedes aegypti*. This, I believe, helped to control the spread of the disease. In August and September, 1949, three more fatalities from the disease occurred in the Buena Vista area. This is about half way across the transisthmian highway and near the upper end of an area of Gatun Lake known as the Rio Gatun basin.

In January, 1950, the first death due to yellow fever west of the Canal occurred on the Atlantic side about 12 miles west of Gatun Lake. On April 15, 1951, another fatal case was reported from Almirante Hospital well up the Atlantic coast. This man was a member of a construction gang surveying a line about 12 kilometers northwest of Almirante. This location is within 50 miles of the boundary line of Costa Rica. The disease has now appeared in epidemic form in two localities in Costa Rica, both of them on the Atlantic drainage slope. One is near Puerto Limon while the other is about 100 hundred miles up the slope.

At the request of the Yellow Fever Service, set up in 1949 jointly by the Health Department of the Panama Canal, the Medical Department of the Army and Navy, the Department of Public Health of the Republic of Panama and

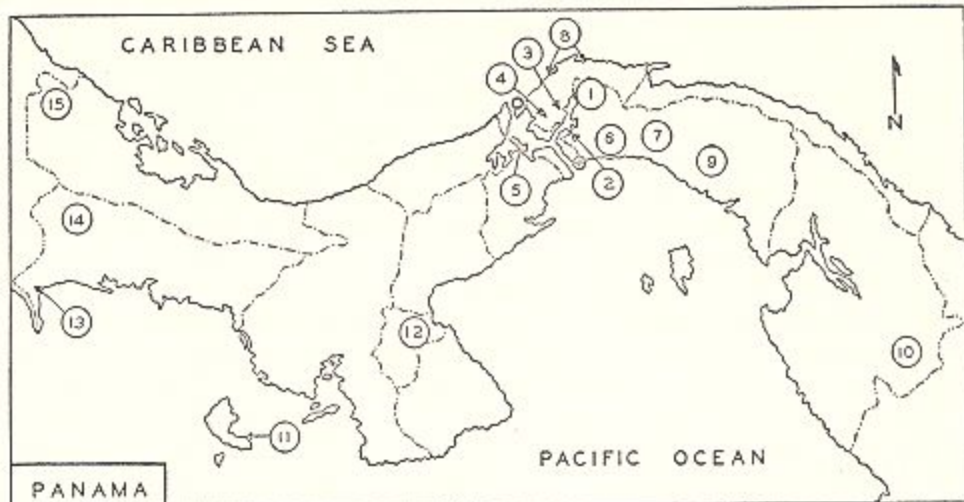
the Pan American Sanitary Bureau, the Gorgas Memorial Laboratory agreed to survey the arboreal forest mammals to determine the wild animal reservoir of jungle yellow fever in the Panama area. Blood specimens were taken from all animals at the site of the kills and at once placed in refrigeration. Later the serum was removed and forwarded to the Carlos Finlay Institute, Bogota, Colombia, for the application of the mouse protection test for immunity to yellow fever. Live animals caught or purchased during this period were tested by the Gorgas Memorial Laboratory.

After the 15 cc blood specimen was taken and placed in refrigeration, the animals were weighed and measured, the sex noted, and a note made as to whether it was an infant, juvenile, a young or very old adult. An autopsy was then performed and notes taken on the organs, the serous cavities, the teeth and the amount of fat storage. Blood films were made. A set of tissues was saved in 10-per cent formalin solution. Skins were taken from a few adult males and females of each species of animal and all skulls were denuded and saved. These were sent to Smithsonian Institution for scientific identification.

The regions surveyed are indicated on the accompanying map of Panama. Results of the mouse protection tests for immunity to yellow fever are shown in Table I, II, and III. Table IV gives the scientific identification of the animals tested.

In January, 1951, a report was received that monkeys were sick and dying near the village of Chorchá in Chiriquí Province, and that some of the people in the village were believed to have yellow fever. Chorchá is 40 minutes by jeep east of David on the highway to Panama City and from January 18 to 20 we searched the area. Two groups of howler monkeys were within hearing distance of the house from which some hospital cases had been received. A group of cebus monkeys was found but they escaped through the trees. A group of nine howlers was found and all of them killed and studied in the usual manner. The mouse protection tests were done by Dr. Enid de Rodaniche of the Gorgas Memorial Laboratory. The tests were all negative.

A common report that comes out of the jungle is that monkeys are sick and on the ground and many of them dying. Since 1915 I have had a chance to visit four regions from which such reports had been received and found none of them correct. Monkeys can be the victims of many diseases and when such reports are received they should be followed up and tests made to establish the diagnosis of yellow fever or to rule it out. Up to date, I have not had the privilege of finding a jungle epidemic of yellow fever in monkeys, yet there is much evidence in wild life surveys that monkeys have at some time during their lives had yellow fever and recovered. Our local species of monkeys while susceptible to the virus, do not suffer from the effects of yellow fever as the *rhesus* monkeys do. The monkeys we have collected on wild life surveys have required from one to three loads of buckshot to get them on the ground and even then some of them lodge in the trees and never fall. On two occasions following our leaving a jungle camp, natives have unexpectedly found groups of monkey carcasses and a report has come in that a serious disease is killing the monkeys. Even though



OUTLINE MAP OF THE REPUBLIC OF PANAMA WITH THE PROVINCES SHOWN IN DOTTED LINES
(Figures in circles indicate the regions surveyed)

1. Chagres River, Panama Province. Headwaters of the Chagres River, Pequeni branch. No monkeys taken here.
2. Chagres River, Panama Province. The eastern boundary of the Canal Zone runs through the center of the regions hunted. Juan Mina was used as the central camp.
3. Chagres River, Quebrada Jiral branch of Rio Palenque, Colon Province. A few miles north of the midbasin of the Chagres River.
4. Chagres River, Rio del Medio and Rio Patos, Colon Province. Two short streams that empty together into Rio Gatun just above and south of its mouth.
5. West bank of Gatun Lake, Panama Province. The shore line of Gatun Lake west of Barro Colorado Island.
6. Cabra River. Midway between the Chagres River and the Chepo-Bayano River, Panama Province.
7. Chepo-Bayano River, Panama Province. The midbasin was hunted including the branches Cañita, Majé, Mono, and Chulugandi.
8. Cacique-Palenque region on the Atlantic coast east of Colon. in Colon Province but near the San Blas islands.
9. Platanar River, Panama Province. The Platanar Branch of the Rio La Maestra which empties into the Pacific near Chimán and not far from the boundary of the Darien Province.
10. Tuira River, Darien Province. Headwaters of the river next to the boundary of Colombia.
11. Coiba Island (Penal Colony).
12. Azuero Peninsula (Santa Maria and Potuga), Herrera Province.
13. Rio Corotó, Chiriqui Province. Extends from the Pacific coast to the boundary of Costa Rica.
14. El Volcan-El Hato region, Chiriqui Province, near the boundary of Costa Rica. Elevation is 4,500 to 6,500 feet.
15. Almirante-Nievecita, Bocas del Toro Province, on the boundary line of Costa Rica behind the Atlantic seacoast.

every monkey carcass was without a head, the idea persisted that yellow fever was abroad.

At the request of Dr. Fred L. Soper, Director of the Pan American Sanitary Bureau, we were asked to make some surveys in southern Mexico similar to those we had made in Panama. Dr. Soper's office financed most of the expenses connected with the expedition. This survey was made in dry season, March 20 to April 25, 1951. It was desired to collect monkeys near Tampico and Vera Cruz but after consulting persons familiar with these areas, it was decided that the many industries in those regions had deforested the area to such a point

TABLE 1
Results of Mouse-Protection Tests for Immunity to Yellow Fever
Animals from eastern Panama (Canal Zone to Colombia), 1949-50

	NUMBER OF ANIMALS COLLECTED	NUMBER OF ANIMALS POSITIVE	PERCENT OF ANIMALS POSITIVE
Region surveyed:			
Tuira River.....	25	18	72.0
Cacique-Palenque.....	36	23	63.9
Cabra River.....	25	15	60.0
Chepo-Bayano River.....	33	16	48.5
Chagres River—Midbasin.....	36	10	27.7
Platanar River.....	46	22	47.8
Total.....	201	104	51.7
Species of animal:			
Howler monkeys.....	63	48	76.2
Whiteface monkeys.....	62	32	51.6
Marmosets.....	27	5	18.5
Night monkeys.....	9	2	22.2
Kinkajous-Olingos.....	17	3	17.6
Red spider monkeys.....	5	5	100.0
Black spider monkeys.....	7	6	85.7
Sloth, 3-toed.....	2	1	50.0
Sloth, 2-toed.....	2	0	0
Squirrel.....	2	0	0
Ocelot.....	1	1	100.0
Porcupine.....	1	0	0
Peccary.....	1	0	0
Anteater.....	1	0	0
Conejo pintado.....	1	1	100.0
Total.....	201	104	51.7

that monkeys could not persist in numbers. We finally decided on the state of Chiapas. The places selected were Palenque and the Chiapas Lumber Company at La Puerta about 60 kilometers beyond Cintalapa in the drainage basin of the Santa Maria river. Both places were on the Atlantic slope (see map). Forty monkeys were killed at Palenque and 37 behind Cintalapa.

The mouse protection tests were done by Dr. Rodaniche of the Gorgas Memorial Laboratory but all sera specimens were divided and half of each was sent

to the Serviço Nacional de Febre Amarela in Rio de Janeiro, Brazil, which reported that 74 or 12% were positive. Only 16 of the 40 blood specimens taken from monkeys in Palenque were considered by our laboratory to be in satisfactory condition to test and 2 of these, or 12.5 per cent, were positive. Both were from black howler monkeys. Of the 37 bloods taken from monkeys behind Cintalapa, 27 were in good shape for the tests and one of these was positive, or 3.7 per cent. This was a spider monkey. The howler monkeys from both locations were

TABLE 2

Results of Mouse-Protection Tests for Immunity to Yellow Fever
Animals from western Panama (Canal Zone to Costa Rica), 1950

	NUMBER OF ANIMALS COLLECTED	NUMBER OF ANIMALS POSITIVE	PERCENT OF ANIMALS POSITIVE
Region surveyed:			
El Volcan-El Hato.....	40	21	52.5
Coiba Island.....	40	15	37.5
Almirante-Nievecita.....	38	10	26.3
Azuero Peninsula.....	40	8	20.0
Rio Corutu.....	41	12	29.2
West Bank of Gatun Lake.....	25	2	8.0
Total.....	224	68	30.3
Species of animal:			
Howler monkeys.....	140	55	39.3
Whiteface monkeys.....	29	6	20.7
Red spider monkeys.....	11	2	18.2
Marmosets (squirrel).....	13	0	0
Marmosets (Chiriqui).....	10	1	10.0
Kinkajous-Olingos.....	13	3	23.1
Coatis.....	2	0	0
Opossums.....	2	1	50.0
Sloth, 3-toed.....	1	0	0
Porcupine.....	1	0	0
Raccoon.....	1	0	0
Squirrel.....	1	0	0
Total.....	224	68	30.3

identified by Smithsonian Institution as *Alouatta palliata pigra* and the spider monkeys as *Ateles geoffroyi vellerosus*.

Dr. Rodaniche has continued the survey for antibodies against yellow fever in the blood of live forest animals obtained by purchase. The intraperitoneal protection test in Swiss mice, with neurotropic virus, has been employed. A total of 91 mammals, including 75 monkeys and 16 other animals, have been examined. Of these three, or 3.3 per cent gave a positive result. The first of these was a juvenile male red spider monkey weighing 2325 grams, captured in the mountains northeast of Madden Dam and the town of Gatuncillo. The second

TABLE 3

Results of Mouse-Protection Test on Infant and Juvenile Monkeys Only

REGIONS	NUMBER EXAMINED	NUMBER POSITIVE	PERCENT POSITIVE	PERCENTAGE FOR TOTAL OF ALL AGES TESTED
Tuira River.....	4	1	25.0	72.0
Cacique-Palenque.....	3	2	66.6	63.9
Cabra River.....	3	1	33.3	60.0
Chepo-Bayano River.....	5	2	40.0	48.5
El Volcan-El Hato.....	5	2	40.0	52.5
Coiba Island.....	3	1	33.3	37.5
Chagres River.....	10	2	20.0	27.7
Rio Platanar.....	8	2	25.0	47.8
Almirante.....	4	0	0	26.3
Azuero Peninsula.....	9	1	11.1	20.0
Rio Corutu.....	1	0	0	29.2
West Bank Gatun Lake.....	2	0	0	8.0
Total.....	57	14	24.6	40.5

TABLE 4

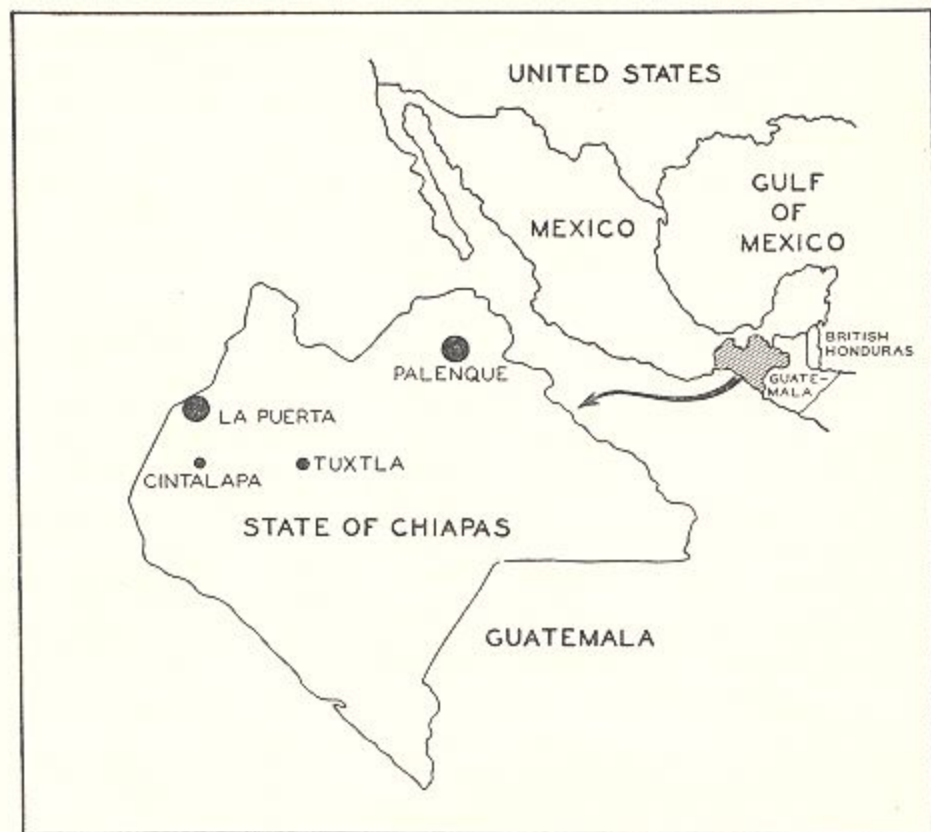
Scientific identifications of animals collected (Smithsonian Institution report)

KIND OF ANIMAL	SCIENTIFIC NAME	LOCALITY WHERE TAKEN
Black howler monkey.....	<i>Alouatta pallita coibensis</i>	Coiba Island.
Black howler monkey.....	<i>Alouatta palliata trabeata</i>	Azuero Peninsula.
Black howler monkey.....	<i>Alouatta palliata palliata</i>	El Volcan.
Black howler monkey.....	<i>Alouatta palliata aequaliorialis</i>	Rio Corutu and Nievcecita.
Whiteface monkey.....	<i>Cebus capucinus capucinus</i>	Rio Platanar.
Whiteface monkey.....	<i>Cebus capucinus imitator</i>	Coiba Island, El Volcan and Almirante.
Red spider monkey.....	<i>Ateles geoffroyi panamensis</i>	Rio Corutu and Almirante.
Black spider monkey.....	<i>Ateles fusciceps robustus</i>	Rio Platanar.
Marmoset, Chiriqui.....	<i>Saimiri orstedii orstedii</i>	Rio Corutu.
Marmoset, squirrel.....	<i>Marikina geoffroyi</i>	Rio Tuira and Rio Platanar.
Kinkajou, isthmian.....	<i>Potos flavus isthmicus</i>	Rio Platanar.
Kinkajou, Chiriqui.....	<i>Potos flavus chiriquensis</i>	Chagres River (Rio del Medio) and Rio Corutu.
Opossum.....	<i>Didelphis marsupialis ctensis</i>	El Volcan and Almirante.
Coati.....	<i>Nasua narica panamensis</i> Allen	Azuero Peninsula.
Sloth, 2-toed.....	<i>Choloepus hoffmani</i> Peters	Chagres River (Rio del Medio).
Sloth, 3-toed.....	<i>Bradypus griseus griseus</i>	Almirante (Nievcecita).
Raccoon.....	<i>Procyon canarivorus panamensis</i>	El Volcan.
Squirrel.....	<i>Sciurus granatensis chiriquensis</i>	El Volcan.
Conejo pintado-paca.....	<i>Cuniculus paca virgatus</i>	Rio Platanar.

was a juvenile male black spider monkey weighing 2050 grams. It was captured in the Bayano River near the place where the human cases of yellow fever first appeared. The third was a young male anteater of the small species *Cyclopes*

didactyls dorsalis. It weighed 185 grams and was captured in the edge of the town of Curundu, Canal Zone.

In June of 1951, yellow fever virus was isolated for the first time during the current outbreak from a 25 year old male agricultural worker who was hospitalized with clinically typical symptoms of yellow fever. He recovered later. He was a native of Costa Rica working in the Province of Bocas del Toro, R. P., near the boundary of Costa Rica, when he became infected. By animal pathogenicity and immunological cross-reactions this strain has been identified definitely as yellow fever. The mouse test of serum taken at the time of his



discharge from Almirante Hospital was positive. The isolation of virus provided a valuable link in the chain of epidemiological data on the status of sylvan yellow fever in Panama. No virus has been recovered from any of the mosquitoes taken in the forest canopy survey although efforts are being continued in a Costa Rican area by Galindo and Trapido. No virus has been recovered to date from any of the monkeys or other animals.

In my opinion there is a wild life reservoir of yellow fever throughout Panama, Central America and southern Mexico. It is probable that a large percentage of cases in humans of rural areas of this geographic region follow a mild course and

go unrecognized. The occasional severe cases with fatal outcome are likely to occur remote from ready transportation, and fail to come to the attention of physicians with adequate hospital facilities, so that these too are not recognized. Although infective individuals might sporadically be transported into an urban area, the residual spraying of dwellings for the control of malaria, together with the direct attack carried on against *Aedes aegypti*, the urban vector, has removed the danger of any large scale urban epidemics such as those which materially affected the development of this area in the past. Vaccination and control or eradication of the *aegypti* mosquito provide an effective barrier to epidemics. All industries using large labor forces in forested regions should vaccinate their employees. Time is rapidly clearing away the primitive forest where the larger species of monkeys live but the small species and the kinkajou will thrive in second growth or bush country. At the present time the howler monkey, the spider monkey and the white face (cebus) are the animals showing the highest rate of positives to the mouse test.