

RESULTS OF RECENT STUDIES OF YELLOW FEVER IN MIDDLE AMERICA

PRELIMINARY NOTE*†

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The Gorgas Memorial Laboratory, Panama, in cooperation with the Pan American Sanitary Bureau, has been engaged for the past seven years in studies relating to the epidemiology of sylvan yellow fever in the Middle American area. During the past year the Gorgas Memorial Laboratory has received financial support for the yellow fever work from the Office of the Surgeon General, Department of the Army.

This disease appeared in Panama in the final months of 1948 after an absence of 43 years and has progressed in wave-like fashion through Costa Rica, Nicaragua, Honduras and into Guatemala where it is presently active in forest primates. While there have been a number of human fatalities recognized (six in Panama, 37 in Costa Rica, 11 in Nicaragua and one in Honduras), serious threat to the human population has been largely circumvented by prompt preventive measures. During the last year and a half the known fatalities have been limited to monkeys. After reaching Honduras in 1953-54 virus activity became inapparent for a period of more than a year and did not again become evident until December 1955. Recent results of the yellow fever studies, which are still in progress, are of such public health significance that it seems desirable to present a preliminary summary.

1. In January 1956 the Gorgas Memorial Laboratory received from the P.A.S.B. office

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† The information presented herewith will appear in amplified and final reports under the authorship of the staff members who actually carried out the field and laboratory studies.

in Guatemala the liver of a dead howling monkey (*Alouatta*) found by Dr. Jorge Boshell in the Rio San Francisco del Mar area on the east coast of Guatemala. Post-mortem degenerative changes were so pronounced that a definite diagnosis could not be made, but it was the opinion of one of us (C. M. J.) that the animal had died of yellow fever. The following month, February 1956, five additional liver specimens from howling monkeys were obtained and sent to the Gorgas Memorial Laboratory by Dr. Boshell. Of these five, four showed the changes characteristic of yellow fever infection (two from near Esparta, Honduras, one from Las Caobas, Guatemala, and one from Rio Blanco, Bananera, Guatemala). The fifth specimen (from La Barra, Guatemala) was negative. An additional howling monkey liver from Pedrera del Tipon, Guatemala, received 12 May 1956, was histologically positive. In addition yellow fever virus was recovered by Dr. Enid de Rodaniche from a glycerinated specimen of the same liver.

2. Since the established South American vectors of yellow fever had been found to be rare in Honduras and completely absent in Guatemala, an attempt was made to determine the species of mosquito responsible for transmission in these areas. Beginning in late March, 1956, mosquitoes were collected in Guatemala under the supervision of Dr. Jorge Boshell in zones in which there was evidence of epizootic activity. They were forwarded on ice to the Gorgas Memorial Laboratory in Panama where they were identified and sorted into batches by species by Drs. Harold Trapido and Pedro Galindo.

Virus isolations were undertaken by Dr. Enid de Rodaniche. Yellow fever virus has been recovered from six such batches of *Haemagogus mesodentatus*, and from two of *H. equinus*, and one of *Sabethes chloropterus*.

3. Transmission experiments had previously been conducted at the Gorgas Memorial Laboratory with Central American species of *Haemagogus* and with *Sabethes chloropterus*. It was shown that *H. equinus*, *H. mesodentatus* and a related but as yet undescribed species from the Pacific side of Guatemala are experimental vectors. One transmission by bite was also obtained with *S. chloropterus*. A report of these experiments is shortly to be submitted for publication (Galindo, Rodaniche and Trapido. "Experimental transmission of yellow fever by Central American species of *Haemagogus* and *Sabethes chloropterus*.")

4. Field work by Drs. Pedro Galindo and Harold Trapido in Panama, Central America, Mexico and Texas has furnished extensive data on the distribution of the above mosquitoes. *Haemagogus mesodentatus* occurs from the Atlantic side rain forest of Panama near the Costa Rican border north along the Atlantic versant of Middle America to the end of the neotropical faunal zone near Tamazunchale, San Luis Potosí, Mexico. The northernmost specimens were collected in a coffee plantation at Ciudad Santos (formerly known as Tancanhuitz), 82 miles southwest of Tampico. The rapid drop in precipitation north of this point limits the range of this forest-inhabiting species. This point is also the northern limit of the continuous distribution of monkeys. Field experience has shown that *H. mesodentatus* is much more abundant in Mexico and Guatemala than it is to the south. It has been taken from near sea-level in Mexico to an elevation of 4,200 feet in Panama. The other closely related but as yet undescribed species which has been shown to transmit yellow fever in the laboratory has been found on the Pacific side from El Salvador north to the southern border of the Mexican state of Sinaloa. This species, or a race

of it, occurs from near sea-level to 5,000 feet in Chiapas. *Haemagogus equinus* has the most extensive range of any Middle American species of this genus. It has been found to be abundant on both the Atlantic and Pacific slopes. On the Pacific slope it has been taken as far north as San Blas, Nayarit, Mexico. The extreme limit of its distribution on the Pacific side has not yet been determined. On the Atlantic side it extends beyond the limits of the neotropical zone to the vicinity of Brownsville, Texas, (See Trapido and Galindo, *Science*, 1956, Vol. 123, p. 634). This species is the least discriminating of any Middle American *Haemagogus* in its choice of habitat. It has been found biting man not only in tropical rain forest and tropical deciduous forest, but also in areas of semi-arid scrub vegetation, coastal mangrove, and even in peridomestic situations. It occurs from sea-level to about 4,500 feet. *Sabethes chloropterus* occurs on both the Atlantic and Pacific slopes and has been taken at a maximum altitude of 4,500 feet in western Panama. Its northern limit approximates that of *H. mesodentatus* near Tamazunchale.

The neotropical forests extend north from the present area of virus activity in Guatemala, across the Peten of Guatemala and the Mexican versant as far as the southeastern corner of the Mexican state of San Luis Potosí, except where it is broken by cultivation and limited areas of savannah and pine woods. This forest carries with it the monkeys and mosquitoes (*Haemagogus mesodentatus* and *H. equinus*, and possibly *Sabethes chloropterus*) which are capable of sustaining yellow fever in nature. Barring the intervention of some climatic factor which cannot be predicted, it is possible that this yellow fever wave which has passed from Panama to Guatemala will continue to the limits of the tropical forests. While one of the vectors, *H. equinus*, is present beyond this point, monkeys are absent. It would be necessary to determine the potential role of other animals as reservoirs before judging the possibility of sustained transmission farther to the north.