

An Historical Outline on the Status of Aedes aegypti, the Mosquito
Vector of Yellow Fever and Dengue Fever in Panama

A. Prior to 1901:

It is likely that both Yellow Fever and Dengue Fever were carried to the New World by men and mosquitoes aboard ships from other parts of the world. It is known that Aedes aegypti, the prime vector of both diseases, originated in Africa. It is a species which lives in close proximity to human dwellings and breeds almost exclusively in man-made containers. It was thus very much at home in water barrels aboard sailing vessels. Dengue and Yellow Fever as well as Malaria were the cause of many of the "fevers" reported in the historical accounts of the early colonization of the Isthmus. The major killer though was Yellow Fever which attains a mortality rate of 20% or more during epidemics. It undoubtedly took its toll of many of the railroad workers who died from illness during the construction of the Panama Railroad in the 1850's and it was reported to be the cause of some 20,000 deaths in the 1880's during the French attempts to construct a canal across the Panama Isthmus.

B. The Canal Construction Era:

The knowledge that mosquitoes transmitted human disease was just beginning to be applied in the early 1900's based on the pioneering work by Carlos Finlay, Walter Reed, Jesse Lazear and Aristides Agramonte in

Cuba on the transmission of Yellow Fever by the Aedes aegypti mosquito. This disease had accounted for as many as 1,200 deaths in Havana each year. However, following the discovery of the vector and the establishment of stringent anti-mosquito methods in that city by Maj. William Crawford Gorgas, the disease rate dropped rapidly with only 5 deaths recorded during the summer of 1901. Although another outbreak of Yellow Fever occurred in Havana in 1905, the disease was quickly brought under control, with the last case of Yellow Fever recorded for Cuba occurring in December 1905.

Upon his assignment to the First Isthmian Canal Commission in 1902, now Col., Gorgas planned his attack on mosquito borne disease in Panama. He arrived on the Isthmus in 1904 along with several of his experienced staff from Havana, and though he lacked administrative support, he continued to carry out an effective mosquito control campaign using oil, sulfur, pyrethrum powder and wire screening. There was, however, one final epidemic of Yellow Fever in Panama City and in the Canal work camps which occurred in May and June of 1905 with 62 cases and six deaths. With control measures directed to the affected areas, this outbreak was quickly stemmed. The final Panama case of urban Yellow Fever was reported from the port city of Colon in June 1906.

C. 1941-1942 Dengue Fever Outbreak:

Aedes aegypti is the sole vector of all four serotypes of Dengue Fever virus in the Americas. Although control measures in Panama had been maintained since the Construction Era, this mosquito was apparently

present in Panama City in high enough numbers to effectively transmit Dengue Fever during the epidemic which occurred in 1941-1942. Epidemiological evidence indicates that this outbreak was due to the Dengue-2 serotype. It is also thought that several Dengue-1 outbreaks may have occurred previous to this date but were not accurately diagnosed.

D. 1948 Jungle Yellow Fever:

Jungle Yellow Fever, first recognized by scientists at the Gorgas Memorial Laboratory in 1939, is caused by the same virus as the urban disease but it is ecologically distinct. In the urban cycle, Aedes aegypti is the only vector in Panama, while in the the jungle cycle, several species of arboreal Haemagogus and Sabethes mosquitoes maintain the disease among monkeys in the forest canopy. These mosquitoes spend their entire life cycle restricted to the upper parts of the forest canopy feeding on monkeys and other tree dwelling mammals and therefore do not normally have contact with man. The virus shows a cycle of approximately 7 to 8 years between monkey epizootics. During such animal to animal transmissions a large percentage of infected monkeys die leaving only a small proportion of immune survivors. The period between outbreaks is apparently determined by the time required for the population of non-immune monkeys to reach a level which will support another epizootic. When transmission is active the virus spreads as a "wave" from areas within Colombia to the Darien jungle and then slowly spreads westward toward the Panama Canal. It may take 3 years to spread as far as the Bayano River. Transmission to humans occurs when timber

cutters fell trees, bringing these infected canopy mosquitoes down to the forest floor. During 1948-1949, 5 human deaths due to Jungle Yellow Fever occurred at a logging site near Pacora, about 20 miles east of Panama City.

This outbreak sparked an extensive Aedes aegypti eradication campaign throughout Panama City, the Canal Zone, Colon and other urban areas of Panama. All water containers in and around houses, the favored breeding sites for aegypti, were emptied and removed or were eliminated. Additional screening was installed and an application of 5% DDT residual spray was made to all houses. The Panama Canal has normally acted as an ecological barrier to the virus, however during the above epizootic, in 1950, it spread across the Canal killing thousands of monkeys and causing some human deaths as it continued on through Central America. Transmission finally died out in the sparsely forested areas in southern Mexico.

E. 1969 Reinfestation by Aedes aegypti:

This species was considered eradicated within the country of Panama until a small breeding focus was found in March 1969, in the slum area of Folks River in Colon and around the adjacent wharf where small fishing and cargo vessels were docked. This area, with its numerous rain barrels and other containers, provided excellent breeding sites for aegypti. Added to these were the likely originating sources, water barrels carried onboard many of the small coastal vessels which travelled between Panama and many of the heavily infested Caribbean ports

where this mosquito breeds uncontrolled. Quick action by U.S. Army Environmental Health Division personnel using insecticide provided by the Division of Sanitation brought the breeding under control, with the Republic's Ministry of Health completing the final eradication in Colon.

F. 1972 Reinfestation in Panama City:

During April-May, 1972, a survey of ten selected Atlantic and Pacific townsites by two Pan American Health Organization officials using Sanitation Division larva hunters, showed no breeding by Aedes aegypti within the borders of the Canal Zone. Later that year, in October, PAHO inspectors did find aegypti larvae in the Pueblo Nuevo section of Panama City. Used tires, imported from the United States through Miami to the Las Minas Bay port in Panama, turned out to be the source. Aedes aegypti have a preference for laying their drought resistant eggs on the moist inner surface of old discarded tires. The eggs remain viable for up to a year after they are laid and hatch into larvae upon being flooded by rain water. The Sanitation Division initially provided insecticide and the loan of equipment for use by SNEM malaria eradication personnel who continued the search for further positive breeding sites.

On September 24, 1973, Pan American Health Organization inspectors found Aedes aegypti larvae in several flower pots in a Panama cemetery, next to the Canal Zone boundary, across from the Quarry Heights U.S. military post. They requested a survey of the areas involved within the Zone and asked also to survey inside the houses. Such an inspection

inside of the Quarry Heights houses was not considered appropriate by the U.S. Army. However, inspectors and larva hunters from the Canal Zone Government's Division of Sanitation and from the U.S. Army's Environmental Health Division did carry out a thorough resurvey of the entire Zone boundary area near the infested cemetery and found no positive breeding sites.

Despite a well organized control effort in Panama, by October, 1973, aegypti mosquitoes had spread to several areas of Panama City as well as to one focus within the Canal Zone in the townsite of Balboa. Eight months later, two other breeding foci were found in the Gavillan district of Balboa (in June, 1974) and the infestation perimeter was expanded to several other districts within Panama City. By September, 1975, infested areas were found as far west as David, Chiriqui province. In November, 1975, positive larval samples were taken from the coastal town of Vera Cruz near Howard Air Force Base and in February, 1976, aegypti larvae were found in the town of La Chorrera near the west border of the Canal Zone. In June, 1976, nearly four years after the finding of the first positive focus, the eradication campaign was finally declared a success by PAHO officials and Panama's Ministry of Health, after all samples from two country-wide surveys had proved negative.

G. 1973 Jungle Yellow Fever:

During the above aegypti infestation, Gorgas Memorial Laboratory scientists found jungle canopy mosquitoes infected with Yellow Fever

virus in Darien province near the Colombian border. The wave spread rapidly westward with 3 human deaths due to Yellow Fever occurring at the Bayano hydroelectric project in workers who were clearing forest trees in the soon to be flooded river basin upstream from the village of Maje. Panama's Ministry of Health immediately began a nationwide Yellow Fever vaccination program, beginning in the area between Bayano and Panama City. The combined efforts of the Gorgas Memorial Laboratory-Middle America Research Unit established canopy collection stations on both sides of the Isthmus using human-bait stations in the jungle canopy and caged sentinel monkeys placed at strategic locations east of the Canal.

In November, 1974, the Division of Sanitation's Medical Entomology Laboratory was assigned to assist GML/MARU with jungle canopy sampling along the Atlantic Ridge mountains near Portobelo. During this period, two new techniques were developed by Dr. Melvin Boreham which proved useful for sampling canopy mosquitoes. One utilized a lightweight thermal fog unit suspended from a pulley system established over the top limbs of up to 100 foot high trees through the aid of a lead weighted arrow and regular archery equipment. Large plastic tarps were placed on the jungle floor and the fogger was started and pulled up into the canopy with a rope. Within seconds after the pyrethrin fog was applied thousands of canopy insects would rain down on the tarps. These were collected and taken back to the lab for separation. Although several excellent mosquito samples were obtained using this technique, a better method was developed by Dr. Boreham using a device called a "clam-shell" trap. A caged spider monkey was obtained from the Gorgas Memorial

Laboratory and the cage was suspended from the same rope and pulley system described above. Around the cage were two large semi-circular cage sections, held apart by a rod at the bottom. This apparatus was pulled up to the level of the high canopy and was left open for about 30 minutes to allow the extremely wary canopy mosquitoes to be attracted to the monkey. The latch holding the "clam-shell" halves apart would then be triggered by a line from the ground to close the trap around the monkey cage. Upon lowering the unit to the jungle floor, the captured Haemagogus and Sabethes mosquitoes were then collected by a battery-powered aspirator and transferred to a flask of liquid nitrogen for transport to the GML/MARU virus laboratory for testing. Experimental results showed that this trap, using an 8 pound monkey, collected more canopy mosquitoes per hour than a man could collect in the same period at special platforms constructed 90 feet high in the jungle canopy, and the "clam-shell" method was much safer. Collaborative efforts stopped in January, 1975, after samples showed no virus activity in the Atlantic coastal mountains.

In July, 1974, GML made plans in coordination with the U.S. Army Southern Command and the U.S. Public Health Service, Communicable Disease Center to create a barrier against the spread of the virus across the Isthmus using military spray aircraft to kill all canopy mosquitoes along a one kilometer swath from Gamboa to Colon. Using money provided by a USAID grant, preliminary tests were made showing that the technique was feasible, using a spray rate of 6 fl. oz. of 95% malathion/acre. Such a mission was considered as a contingency plan,

but the actual spray flight was not necessary due to no further findings of the virus beyond the Bayano region.

Since dense stands of forest are required for breeding by the canopy mosquito vectors of jungle Yellow Fever, and in that extensive deforestation has taken place east of the Panama Canal in recent years, it is highly unlikely that any future "wave" of this virus would be able to spread to the vicinity of Panama City or other residential areas near the Canal. There is, of course, the possibility that persons infected in the Darien could carry the virus into urban areas. However, many Panamanian citizens have been vaccinated against Yellow Fever, therefore the chance of having a major outbreak of urban disease is somewhat diminished.

H. The Continuing Threat of Reinfestation:

Vessels arriving in Panama from ports throughout the Caribbean basin carry with them the threat of reinfestation by Aedes aegypti. Although international quarantine regulations require the application of adulticidal aerosols by the boarding officer, the application may not be thorough due to time limitations and the inaccessibility of certain parts of the ship. Panama inspections of vessels docked at Panamanian ports in Cristobal and Balboa have found active breeding by this mosquito aboard ship on numerous occasions. Ports of embarkation in Colombia, Venezuela, and most of the smaller Caribbean islands provide little or no control of this vector species.

I. 1983 Reinfestation in Diablo townsite:

On June 6, 1983, two active breeding sites of Aedes aegypti were found near two separate residences near the waterfront in the Commission townsite of Diablo. As soon as the samples were verified by the Entomology Unit lab, planning for the eradication campaign got underway. Spraying of all possible breeding sources with malathion began the following week and adulticide applications using portable "swing-fog" units and using vehicle mounted ULV fog machines were made in the early morning and evening. Along with this spray effort, intensified larva hunting turned up four more positive foci the first day of the operation. On June 13, a breeding site was found several miles away near a residence in the La Boca townsite and another focus was found at the nearby Port of Balboa. Eradication efforts were immediately directed to include these areas. Three more positive foci within Diablo were found on June 17. Prior to this time, only the areas outside residences had been inspected, however, in light of the new findings, the PAHO technical staff recommended that all quarters within Commission residential areas be visited by inspection crews.

Upon establishment of the inspection protocol, on June 20, joint teams of SNEM and Panama Canal Commission Sanitation Management Branch larva hunters began a house to house search for breeding sources within employee quarters beginning in Diablo and La Boca, with the Commission Fire Division inspectors providing bilingual support. It was agreed upon to inspect every occupied or vacant quarters in both townsites and to inspect one third of all other Commission employee residences on both

sides of the Isthmus. Though no further breeding was found, on June 21 a coordinated respraying of both townsites was carried out using malathion larvicide. In final analysis, the infestation appeared to have originated from either a Cuban or a Colombian vessel, both of which were anchored just offshore from Diablo. It also appears that breeding in the townsite had gone undetected for several weeks. Interestingly, all of the Diablo foci were in a line leading directly from the vessel anchorage and in line with the prevailing wind direction in that location. The joint Commission/SNEM teams worked well together in this eradication effort and such teamwork led to a very successful outcome.

J. 1985 Reinfestation of San Miguelito Area:

With the exception of several positive findings aboard ships arriving from Caribbean ports at Cristobal, no major reinfestation had occurred since the Diablo incident recounted above. But, on August 1, 1985, a positive breeding site was found at a bus repair facility along the Transisthmian highway not far from the San Miguelito district of Panama City. Further searches found more breeding north of the initial site, with major breeding being found in a pile of more than 500 used tires at the Panagrua construction company. All stages of the life cycle were present in abundance including many flying adult mosquitoes. Across the highway at Trail Movil, a container service company, more infested tires were found. It is possible that the first hatch of Aedes aegypti larvae occurred here in used tires imported in shipping containers from infested areas either in the U.S. or Colombia. Adults from this site probably spread the infestation to the tires at Panagrua and

this then resulted in a major breeding source from which other nearby areas were invaded. At times adult female aegypti may be spread to other areas of the city inside vehicles which have been parked near such a breeding source.

Eradication measures began on August 8 and from that date to September 9, some 1,350 homes in the San Isidro and San Miguelito districts had been treated. Both malathion emulsion and temephos (Abate) granules are being used to control larval breeding and vehicle-mounted ULV fog generators, plus portable "swing foggers", are being directed against adult mosquitoes. At the present time, spraying is carried out within a radius of 300 meters from any positive finding. Inspections continue beyond this perimeter and if additional foci are found, the area of treatment is expanded to include another 300 meter radius. At the present time, the perimeter of the affected area has been expanded several times and includes an area several kilometers wide mainly east of the Transisthmian highway from a point near the southern limits of Las Cumbres to San Miguelito just beyond the Tumba Muerto intersection with the highway.

The Panama Canal Commission has loaned four drums of insecticide to SNEM spray teams to allow them to begin their program as soon as possible in hopes of limiting the spread of this mosquito. Only time will reveal the full extent of this current aegypti infestation.

K. Dengue Hemorrhagic Fever in Retrospect:

Dengue Fever has been the cause of millions of cases of disease in the Americas since the first recorded outbreak in the early 1880's. The disease is usually only debilitating over the short term and seldom results in death. However, in May, 1981, the Ministry of Health of Cuba reported a widespread epidemic of Dengue-2 virus. About 350,000 cases were reported by the end of August with approximately 10,000 requiring hospitalization and with 159 deaths. This was the first confirmed instance of the hemorrhagic form of Dengue Fever in the Americas. In this case, it may have been due to an especially virulent strain of the virus brought back to Cuba by military troops returning from Africa.

PAHO officials recently reported that an epidemic of Dengue Fever had occurred on the island of Aruba in February, 1985. There were 30,000 cases of Dengue reported, which is alarming considering that this is half of the total population of the island. Although no deaths were reported, this occurrence is of special concern. It is possible that such widespread outbreaks could occur in Panama should Aedes aegypti establish a foothold here once again.

Melvin M. Boreham, Ph.D.
Chief, Entomology Unit
Sanitation & Grounds Management Division