OBSERVATIONS ON MOSQUITO AND MALARIA CONTROL IN THE CARIBBEAN AREA. PART IV—PUERTO RICO

BY

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En route from Trinidad to the States late in April 1946, the senior author stopped over for a few days in Puerto Rico. Here a bird's-eye picture of mosquito and malaria control was given him by the junior author.

Briefly, Puerto Rico presents an attractive combination of many desirable physical and climatic features, especially for the planter and for the tourist. The island is primarily agricultural, and much land is given to the raising of sugarcane, tobacco, coffee, citrus fruits, and pineapples. The geographical position of the island within the trade-wind belt, combined with its high elevation above sea level, makes it one of the most favorable regions within the tropics. The name "Riviera of the Caribbean," often applied to the island of Trinidad, is equally appropriate for lovely Puerto Rico.

While flying over the island, one sees only a confused mass of small mountains. They really are part of a well-defined ridge, the Cordilleras, which extends the full length of the 150-mile-long island. The highest peaks range from 2,000 to almost 4,400 feet. The lowlands are found only along the coast in a narrow belt not more than 5 miles in width.

The annual mean temperature for the island is about 73 degrees Fahrenheit during the coolest month (January) and about 79 degrees during the warmest month (August). The differences in

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temperature between shade and sunshine are much greater than as we know them in the States. Also the difference between day and night temperatures is considerably greater than the difference between the average summer and average winter temperature. The nights are comfortably cool, and the day's heat is tempered by the refreshing and persistent trade winds blowing from the eastern sea and by the decreasing relative humidity.

The average annual rainfall is close to 80 inches. In the mountainous sections it may exceed 135 inches, whereas along certain portions of the south coast it is less than 40 inches.

It is unfortunate that Puerto Rico with such an agreeable climate should have been inflicted with malaria. This disease has long constituted a serious health problem on the island, and although it is most severe along the coast no part of the island is entirely free from the ravages of the disease. As many as 1,000 or even 2,000 deaths annually have been caused by malaria alone. During World War II, over a million dollars was spent in 1942 and 1943 by various insular and federal government agencies in efforts to curb it.

MOSQUITOES OF PUERTO RICO

In 1937 Tulloch(1) reported 27 species of mosquitoes in Puerto Rico, but subsequent collecting and study have given us 29 species which appear authentic. The most important species may be grouped as follows according to their breeding places:

Stagnant water: *Culex quinquefasciatus* Say, *C. nigripalpus* Theo., *Aedes aegypti* (L.), and *Anopheles albimanus* Wied.

Field water: *Culex pilosus* (D. and K.), *Aedes taeniorhynchus* (Wied.), *A. tortilis* (Theo.), *A. grabhamii* Theo., *Psorophora pygmaea* (Theo.), and *P. confinnis* (L.A.).

Crab holes: *Deinocerites cancer* Theo.

Tree holes: *Aedes mediovittatus* (Coq.) and *Megarhinus portoricensis* von Roeder.

Axils of air plants: *Culex americanus* Neveu-Lemaire, *Megarhinus portoricensis,* and *Wyeomyia* sp.

Of the three species of *Anopheles* found in Puerto Rico—*A. albimanus, A. grabhamii,* and *A. vestitipennis* D. and K.—*albimanus* is by far the most abundant in larval, animal-bait-trap, and light-trap collections. It is the most abundant species on the coastal plains of Puerto Rico, that portion of the island in which the highest malaria rates occur. Ever since the pioneer work of Dr. Walter C. Earle and the Rockefeller Foundation from 1920 to 1924, *albimanus* has been considered the most important species on this island with regard to malaria transmission. During World War II malaria control activities of the United States Public Health Service, Army, Navy, and the Puerto Rico Department of Public Health were directed toward control of this species. "Species sanitation" in Puerto Rico was directed toward control of *A. albimanus* in the same way that control programs in the United States were directed against *A. quadrimaculatus* Say.

Anopheles albimanus larvae breed in various aquatic situations (Meyer 2). They prefer clean water with some algal growths or nonvital flotage, such as sugarcane trash, fully exposed to the sunlight. They do occur, however, in densely shaded situations, such as crab holes and mangrove swamps, during the dry seasons. They may occur in rather large bodies of water, such as irrigation reservoirs, or in very small ones, such as cattle hoofprints filled with water, especially during the rainy season. In Puerto Rico this species can breed in brackish water containing as much as 50 percent of sea water. Breeding of *albimanus* decreases markedly in water containing more than 50 percent of sea water, and Hurlbut(3) has shown that the Puerto Rican strain of this species cannot reproduce in water containing more than 75 percent of sea water. As a result of his work *albimanus* breeding has been eliminated in some brackish-water mangrove swamps on Vieques Island and in parts of Puerto Rico by ditching to bring sea water into such areas. Here is a good example of mosquito control by ecological means.

Collections of *Anopheles albimanus* are made in routine manner using the Caribbean-type animal bait trap or the New Jersey-type light trap. There are usually two peaks in *albimanus* populations, one at the beginning of the rainy season, in April, and another toward the end of the rainy season, in October.

Since 1930 maximum bait-trap collections from individual traps for a single night range from 3,000 to 5,500 whereas the maximum light-trap collection from 1942 to date is 1,350. Studies by the Department of Public Health and other control agencies in Puerto Rico have indicated that the light trap may collect more specimens of *albimanus* than an animal-bait trap nearby, but there is a cyclical fluctuation in numbers of specimens caught in light traps as the moon waxes and wanes, making it difficult to interpret light-trap data.

Anopheles grabhamii is the second most abundant species of malaria mosquito in Puerto Rico. It breeds by preference in shady situations, particularly in irrigation or drainage ditches in sugarcane fields, in mangrove swamps, or in damp meadows with tall grass or sedges. It is most abundant during the fall and winter months, and some animal-bait traps have contained as many as 1,340 specimens of this species in a single night. It is found more frequently in daytime resting places, such as in barns or under houses, than is *A. albimanus,* but its importance in malaria control in Puerto Rico has not been demonstrated at the present time.

Anopheles vestitipennis is the rarest of the three malaria mosquitoes in Puerto Rico. The larvae breed in densely shaded water areas and, so far as is known, only in fresh water. It is a rare and locally distributed species. The largest collection that has been made in a bait trap contained 263 specimens.

MALARIA CONTROL

Until 1944 malaria-control operations in Puerto Rico consisted chiefly of drainage, frequently with a pumping station at the outlet portion of the drainage system, and larviciding with paris green or diesel oil. Neither of these methods was entirely satisfactory in preventing seasonal rises in *Anopheles albimanus* during the rainy season, although control operations did shorten the period when collections were high. In 1944 the United States Army introduced airplane dispersal of DDT (5- to 10-percent solution of diesel oil), which was markedly successful in reducing counts of this species in a few weeks. In 1945 the Navy began similar control operations with airplanes. In 1946 both the Army and the Navy were using airplanes equipped with thermal aerosol apparatus with marked success. In 1945 the Public Health Service (Neill 4) began larviciding with a 0.5-percent emulsion of DDT in diesel oil with Triton B-1956 (a phthalic glyceryl alkyd resin) as emulsifier. This larvicide gave much better control, especially during the rainy season, than paris green or diesel oil had done during the years 1942 to 1945.

In 1944 the United States Public Health Service, the Puerto Rican Department of Public Health, and the School of Tropical Medicine began a residual DDT spray program in the village of Humacao Playa. A preliminary report on the results of this first year's work has already been published (Stephens and Pratt 5). Residual DDT spraying has given such promise of reducing the malaria rate in rural areas where malaria control by drainage or larviciding is not economically feasible, that the Puerto Rican Department of Public Health has begun an extensive program covering much of the coastal area of the island. Preliminary surveys in several of the sprayed villages indicate a significant reduction in malaria.

DDT has shown itself to be such an excellent insecticide against *Anopheles albimanus* that the Puerto Rican Department of Public Health is considering a campaign to eradicate this species from the island (Stage 6). Henderson(7) has discussed such a program in detail and a practical

test may be initiated on Vieques Island (an island 20 miles long by 3 miles wide), some 6 miles east of Puerto Rico in the near future.

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