OBSERVATIONS ON MOSQUITO AND MALARIA CONTROL IN THE CARIBBEAN AREA

PART II. BRITISH GUIANA

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After leaving Suriname (Dutch Guiana), the senior author stopped at British Guiana to observe some of the mosquito and malaria problems in that colony.

There are probably few countries where malaria constitutes a more serious problem than in British Guiana. Both on the coast and in the interior, there is a high incidence of this devitalizing disease, and no doubt it is the main obstacle to development and progress. In a population of about 350,000 persons, malaria has accounted annually for an average of two deaths per 1,000 inhabitants. This is a poor index of the damage caused by the disease, as it does not take into account the much larger number of deaths caused indirectly by chronic and repeated malaria infections, such as anemia, nephritis, and prematurity and congenital debility in infants born to mothers afflicted with malaria. In the rural districts and in the city suburbs few children escape this infection. Dangerous convulsive forms of the disease are frequent.

In the interior only the aboriginal Indian builds his village on high ground, on sand or gravel. The immigrants—Negroes, Chinese, Portuguese, East Indians, and their mixtures—brought to the colony as slaves or as indentured laborers for the plantations, have settled on the alluvial coastland and on the densely forested, malarial mud flats which form the floor of the river valleys below the first rapids. Most of the inhabitants are exposed to the ravages of malaria throughout their lives, and they accept the disease as inevitable.

Malaria is by no means the only important mosquito-borne disease in British Guiana. Filariasis is a major problem in the cities and large villages, and yellow fever is always a potential danger because it has been recorded from the interior as jungle fever.

The diverse breeding habits of the mosquitoes which transmit these diseases—*Anopheles* spp., *Culex quinquefasciatus* Say, and *Aedes aegypti* (L.)—make the problem of mosquito control and mosquito-borne diseases a complex and difficult one.

In British Guiana, as in Dutch Guiana, the colony lives mainly by its agriculture, and in both countries the staple crops, rice and sugar cane, are dependent on extensive irrigation in spite of an annual rainfall in the neighborhood of 90 inches. There is a great difference, however, in the malaria rate of the two countries; this is proportionate to the degree of development of irrigation and wet cultivation. In Dutch Guiana there are only epidemic outbreaks of the disease along the coastal fringe, whereas in British Guiana the coastal malaria bears the same characters as the Dutch Guiana jungle malaria, high incidence and high rate of malignant tertian infections. In both Guianas *Anopheles darlingi* Root seems to be the principal culprit. This species is strictly a night flyer and extremely susceptible to desiccation; hence it confines itself largely to the low forests and similar sheltered, damp areas where the night air is saturated with moisture. The constant ocean breeze which blows along the

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Dutch and British Guiana coasts is inimical to its welfare, wherever the primitive coastal conditions have not been modified by the introduction of sea defenses, drainage, irrigation, and the planting of crops and trees offering suitable conditions of humid shelter.

The topography and agricultural practices in British Guiana are especially conducive to mosquito breeding. This is especially true in regard to anophelines. Much of the land behind the dikes along the coast is below high-tide sea level. Indeed, sea water, in some sections, finds its way inland for several miles. The cane and rice fields are blocked off and separated by ditches, which eventually drain toward the sea, where either pumps or tide gates empty them at a low tide. Irrigation canals are everywhere, and in no place can a person walk more than a few hundred feet in any direction without crossing one. The practice of flooding the fallow cane fields (Fig. 1) for six months to a year after three or four crops have been harvested also contributes to a bountiful crop of mosquitoes.

So far 15 species of *Anopheles* have been identified in British Guiana, but the malaria vector is *darlingi*. The species *albitarsis* Arrib, *aquasalis* Curry, *oswaldoi* (Pery.), and *triannulatus* (Neiva and Pinto) are all common, but essentially zoöphilous. They are found mainly in stables or on animals in the open, and infrequently bite man; when found in houses they are seldom engorged with blood. *A. darlingi,* however, bites man selectively and is found in houses in large numbers before and after biting.

On the coast *Anopheles darlingi* breeds mainly in fairly large bodies of fresh water, such as irrigation canals, rice fields, flooded cane fields, and pastures. In the interior it prefers white water as found in seepage swamps, in forest streams, or in rain-water collections. On the savannahs of the interior it occurs in white-water ponds, lakes, and streams mainly along the forested course of the larger

FIG. 1. Fallow cane fields are flooded for several months after three or four crops have been harvested. These fields produce anopheline mosquitoes in great numbers.

rivers. It is not found in the highly acid, brown, peaty waters so characteristic of the forest areas of the interior. In nature this species is rarely found in waters containing over 200 milligrams of sodium chloride per liter, but in the laboratory much higher concentrations are tolerated. *A. darlingi* is rarely found in waters with a pH under 5.5; the optimum range is 5.8 to 6.8. Salinity and acidity of surface waters therefore limit its distribution. The highly acid waters in the interior and the highly saline waters along the coast are important limiting factors.

Anopheles aquasalis and *A. oswaldoi*, on the other hand, can breed in sea water containing as much as 28 grams of sodium chloride per liter. In some of the higher savannahs on the Brazilian border, *albitarsis, strodei* Root, *aquasalis,* and *triannulatus* are widespread and very numerous. Apparently these are not efficient vectors, because malaria is not a severe problem where they and other anophelines except *darlingi* exist.

All the data collected from malaria surveys conducted during the last 10 years by the junior author, throughout the coastland from the Courantyne to the Pomeroon Rivers, indicate clearly that sea defenses, irrigation, and the cultivations they foster, when used without due discrimination between agricultural and residential lands, bring about the establishment of *Anopheles darlingi* and subsequently endemic malaria.

The Malaria Research Service, Medical Department, British Guiana, made the first practical demonstration in South America that the numbers of *Anopheles* mosquitoes and the incidence of malaria can be substantially reduced by applying DDT residual sprays (Fig. 2).[1] The preliminary experiments were initiated by C. B. Symes, A. B. Hadaway, and the junior author on January 28, 1945. These ex-

[1] The gasoline-motor gear pump used in these experiments was assembled and loaned by the Orlando, Florida, laboratory of the Bureau of Entomology and Plant Quarantine.

FIG. 2. In British Guiana homes occupied by laborers were first treated with DDT residual sprays on January 28, 1945.

periments have been continued and greatly expanded by the junior author with funds supplemented by the Colonial Development and Welfare Fund and the British Guiana Sugar Producers' Association. The results have been eminently successful. It now appears that the vicious, house-haunting, and very efficient vector of malaria, *Anopheles darlingi,* is in grave danger of extermination because of DDT and a new technique for applying it. DDT residual sprays are equally potent against *Aedes aegypti,* the carrier of yellow fever, and only slightly less toxic to *Culex quinquefasciatus,* the vector of filariasis.

During 1945 slightly more than 1,000 pounds of DDT were used. This amount was increased by 6,500 pounds the first half of 1946 and orders have been placed for 5½ tons more. The average total cost per 1,000 square feet of surface treated was slightly less than $1 (British Guiana). More than 20,000 persons were under DDT protection on June 30, 1946 and plans are under way to include an additional 55,000.

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