OBSERVATIONS ON MOSQUITOES AND MALARIA CONTROL IN THE CARIBBEAN AREA. PART III—TRINIDAD

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After leaving British Guiana in April 1946, the senior author stopped over for a few days on Trinidad, where two difficult and totally different problems of anopheline control were being studied. This work has been carried on for several years, as a result of malaria surveys of the Crown Colony of Trinidad and Tobago that were organized in 1941 by Dr. W. G. Downs. Later the work was placed under the direction of R. C. Shannon, and in 1943 a Malaria Division of the Government was formed, which continues to function with the junior author as the medical officer in charge.

Anophelines of Trinidad and Tobago

Fifteen species of anophelines have been found in the Colony and have been fully reported on in the Malaria Survey of Trinidad. Of these species, only five (numbered in list that follows) are commonly encountered. *Anopheles pseudopunctipennis* Theob., which has previously been reported on the island, has not been found. *A. pessoai* G. and L., *A. punctimacula* D. and K., *A. intermedius* Chagas, *A. homunculus* Komp, *A. anoplus* Komp, and *A. (Kerteszia)* sp. are new species not previously reported in Trinidad.

A. aquasalis Curry (1). The most important vector of malaria; breeds in brackish water, in coastal swamps, and in river mouths, but is also found in fresh-water streams, ponds, and dams.

A. oswaldoi Perry (2). Associated with *A. aquasalis* in fresh-water collections; a zoophilic species.

A. albitarsis (3) L.Arr. Breeds in rice fields, ponds, and drains; sometimes associated with *A. aquasalis.* This species is suspected of being a minor vector.

A. pessoai. A rare species; taken in collections at Piarco, Valencia, and Moruga. May have been brought to the colony by aircraft.

A. neomaculipalpus (4) Curry. Found in savannah pools, rice fields, and other small and temporary main pools. This species is suspected of being a minor vector.

A. apicimacula D. and K., *A. punctimacula, A. intermedius,* and *A. mediopunctatus* Theob. These are rare mosquitoes found breeding in pools and streams in forest country.

A. eiseni Coq. A rare forest mosquito found in streams and pools.

A. nimbus Theob. A rare forest mosquito.

A. bellator D. and K.(5) An important vector of malaria; breeds in bromeliads, especially the large tank species (e.g., *Gravisia* spp.), growing on immortelle trees partly exposed to sunlight. This mosquito is important only in the heavy rainfall zones (over 90 inches of rain) of Trinidad where the plants hold enough water to support breeding the year round, and so maintain high mosquito densities.

A. homunculus. This is a bromeliad-breeding anopheline and is found associated with *A. bellator.* It prefers, however, to breed in the smaller plants and in positions of greater humidity and less exposure to sunlgiht.

A. anoplus and *A. (Kerteszia)* sp. These two species were found among material of *A. homunculus* collected in the Valencia area of north Trinidad, and were identified by dissection of the male terminalia.

Of these anophelines only two, *aquasalis* and *bellator,* are important vectors of malaria. The areas of high malaria incidence in Trinidad are therefore found wherever these two species are abundant—that is, along coastal areas and in the heavy rainfall zones. Spleen rates as high as 80 per cent have been found in both areas. In other parts of the island malaria rates are generally low.

The *Anopheles aquasalis* Problem

Two or three miles southeast of Port-of-Spain lie two large salt marshes, the Laventille and Caroni swamps. Several hundred acres of black, white, and red

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mangrove cover the area, and *Anopheles aquasalis*, breeds there in abundance during the greater part of each year. This anopheline is strongly zoophilic. Tens of thousands of this species may be seen nightly in a stable near the marshes where about 100 water buffaloes are quartered. The density of this species appears to be great enough to maintain a high malaria incidence in the surrounding villages.

Apparently *aquasalis* is a reasonably strong flier, because an epidemic of malaria soon broke out in a newly constructed village extending from 1 to 3 miles from the edge of the Laventille swamp. From a casual inspection of the village site one would discount the possibility of a malaria hazard. The village is at least 1 mile from the border of *aquasalis* breeding areas, and beyond a ridge several hundred feet above sea level with topography that permits excellent drainage. The development and use of a so-called dawn trap, however, proved that *aquasalis* was abundant.

The dawn trap was constructed by R. C. Shannon to take advantage of two of the dominant tendencies of this anopheline, namely to enter houses and stables at night for blood and to leave them at dawn. With this trap information has been obtained to prove that *aquasalis* has migrated inland over rough country as far as 5 miles from its salt-marsh breeding grounds. Twelve of these traps have been used in this village during the last 4 years (1943–1946), with an average yearly capture of more than half a million *aquasalis* mosquitoes.

The spring cleaning operations of clearing, draining, grading, and oiling are often used against *aquasalis* and give excellent results in several small isolated areas where more permanent measures would be uneconomic. In more populated areas, particularly where *aquasalis* is found to be breeding largely in the blocked mouths of small streams, a special low-tide culvert with a seahead [3] is used with great success.

[3] Designed by C. E. Newbold, a former anti-malaria engineer.

Automatic siphon-flush arrangements have also proved useful, especially on some of the small streams.

There are several thickly populated areas in the colony that are located close to large swamps where it is not possible to carry out permanent antimalarial measures owing to limited resources. In these areas residual spraying with DDT has been successful, and more than 20,000 houses have been so treated.

THE *Anopheles bellator* PROBLEM

One of the most intriguing malaria problems in the world may be found in the cacao estates in the wetter portions of Trinidad. Throughout great sections forests have been replaced by plantations of cacao. Here the cacao tree is protected by tall, regularly interplanted shade trees, the immortelles (*Erythrina glauca* and *E. micropteryx*). A large human population obtains its livelihood within or near these artificial forests. Thus the cacao industry is responsible for the contact between man and the malaria vector.

A considerable flora of sun epiphytes grows on the immortelle trees. In fact every tree supports these air plants. There are many species, but the bromeliads are the most numerous. Not all of these plants are hosts to *Anopheles bellator*, but one of the most common large ones, *Gravisia aquilega* L. (Fig. 1), is by far

FIG. 1. *Gravisia aquilega*, host plant of *Anopheles bellator*, in an immortelle tree.

its most important host plant. Rarely can one find a plant of this species in which *bellator* larvae are absent. Another common large bromeliad is *Aechmea nudicaulis,* but in this species *bellator* is seldom, if ever, found. Inaccessibility of the water surface may exclude *bellator* from this bromeliad. These plants have high, narrow, tubular rosettes of leaves, which are stiffly erect above the interfoliar water.

The peculiar breeding habit of *bellator* precludes any practical attempt to control it with DDT residual sprays. This species is rarely seen within dwellings. It is, however, active throughout the day, and freely attacks laborers in the shade of the cacao trees on damp days. These mosquitoes also bite people resting on their verandas in the evening.

It has not been found practicable to destroy these bromeliads by hand, because the cost is prohibitive. Furthermore, few laborers can be found who are willing to climb these trees. The immortelle trees are high, and the limbs are brittle and break easily. They are also covered with large thorns, and because of the luxuriant growth of epiphytes they usually support large numbers of ants, scorpions, spiders, and snakes, which have caused serious accidents.

The difference between the bromeliad leaves and the leaves of the cacao and immortelle has made it possible to use several chemical sprays as bromelicides. A 0.5 per cent solution of copper sulfate has given the best results, although lead arsenate at a concentration of 0.1 per cent is also effective.

The spraying equipment developed by the U. S. Bureau of Entomology and Plant Quarantine (Fig. 2) is the most satisfactory device tried for applying these sprays. Sufficient power is developed by the pumping unit so that it can be left outside the area to be treated and connected with hose lines extending into the plantation for several hundred feet.

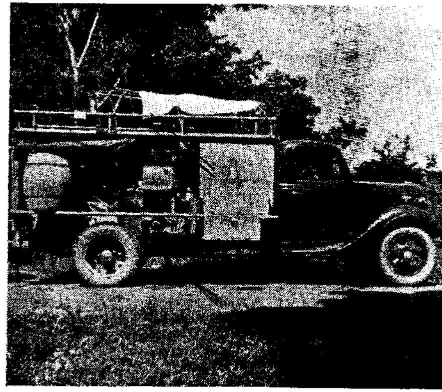

FIG. 2. Equipment used in applying copper sulfate sprays to destroy bromeliads.

Here again is an example of man-made malaria. Plans are now under way to abandon the interplanted immortelle shade trees and protect the cacao trees with windbreaks. Such a change, which is now being encouraged by the Government, would soon remove the bromeliad-*Anopheles bellator* complex, and consequently endemic bromeliad malaria should disappear from Trinidad.

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