una a tres semanas. También hubo que tratar al mismo tiempo todos los arroyos en una zona relativamente amplia a fin de reducir el número de adultos que infiltraban una zona cercana para poner huevos y neutralizar rápidamente el efecto del tratamiento con el larvicida.

Estas corrientes claras, procedentes de las tierras altas, son las principales fuentes de agua potable utilizadas por los indios. Esta agua se emplea también como fuente de fuerza motriz, para lavar y manipular el café y finalmente para fines de irrigación. La aplicación de larvicida concentrado en el nacimiento de esos arroyos, aunque eficaz, presentó los siguientes problemas: (1) envenenamiento de los abastecimientos de agua; (2) exterminación de las abejas e insectos beneficiosos que vienen a abastecerse de agua en las cañadas que conducen a las plantas eléctricas durante las estaciones sumamente secas; (3) la introducción de elementos tóxicos en el beneficio del café; y (4) la aplicación de insecticidas a las plantas por medio de la irrigación. En la práctica se encontró que dichos tratamientos destruían prácticamente todos los depredadores asociados con las larvas de simulídeos inclusive insectos, crustáceos y peces. Se observó que el abandono de dichos tratamientos después de una estación resultó hasta en un 25% de aumento en la abundancia de Simulium sobre el número descubierto en un período comparable del año anterior antes de haberse iniciado las operaciones larvicidas. Esos hallazgos ilustran algunas de las limitaciones en la selección y empleo de larvicidas de ese tipo.

Tales experiencias en la América Central indican brevemente algunas de las situaciones que se confrontarán al emplear medidas temporales para la destrucción de mosquitos y otros dipteros con estados larvarios acuáticos.

Las consideraciones económicas y las dificultades confrontadas en el mantenimiento de estructuras de drenaje semipermanentes están convirtiendo en la actualidad a los trópicos en un campo especialmente fértil para la aplicación de los métodos químicos más modernos en el control de los mosquitos y otros insectos en zonas limitadas.

SOME MOSQUITO CONTROL PROBLEMS ALONG THE INTER-AMERICAN HIGHWAY IN CENTRAL AMERICA

By Daniel M. Jobbins*
American Highway and its alternate or connecting routes. With this greater movement of people and commodities, long anticipated problems of a sanitary nature are beginning to materialize. Important among these is the prevention of malaria and other mosquito borne disease transmission. The use of motor vehicles may bring the international traveler in contact with disease transmitting and pest mosquitoes at such points as obligatory stops for customs and immigration inspection at frontiers and halts along the way for supplies and the servicing of vehicles. Due to the increased speed of travel new points for overnight stops are being required at intervals different from the spacing of the older cities. The transport of agricultural products by truck tends to cause roads through mosquito infested coastal lowlands to be preferred to winding highland routes wherever possible because of favorable operating and maintenance costs on vehicles.

Fortunately the unprecedented number of permanent and semi-permanent mosquito control projects conducted during the war by the several Central American governments in cooperation with the Office of the Coordinator of Inter-American Affairs provides many of the larger centers in malarious areas with a reasonable degree of protection from mosquito vectors of this disease so that the highway traveler stopping at these points is not likely to experience mosquito annoyance.

In the smaller towns in the rural lowlands, however, there exist mosquito annoyance and malaria hazards of considerable proportions. Local funds are frequently inadequate for conducting or maintaining anti-mosquito work of a permanent nature and the economic importance of individual localities is too often insufficient to justify the use of national funds which may be primarily committed to the maintenance of existing large scale projects. It is in such places that the overland traveler comes in contact with mosquitoes which may interfere with his comfort and affect his health.

Beginning early in 1943 and continuing for more than two years, the Pan American Sanitary Bureau conducted a series of sanitary surveys of the smaller but strategically located communities along the Inter-American Highway in all countries between Panama and the United States. This work was done in cooperation with the governments of the various countries and the technical assistance of U. S. Public Health Service personnel. The principal purpose of the work was the evaluation of sanitary conditions in relation to the future use of the highway. Mosquito and malaria surveys and the analyses of control programs with the preparation of recommendations were an important part of this work. Previous knowledge that mosquito borne disease hazards exist, primarily in areas below 1000 feet, was confirmed as was their extreme importance in populated areas near bodies of water at elevations less than 400 feet above sea level. In general, at elevations above 3000 feet malaria and its vectors are found only sporadically and in restricted areas in Central America. Isolated foci in highlands increased in numbers during the period of highway construction due to the return of infected laborers to their homes where the highland Anopheline species had not previously had sufficiently large reservoirs of infected humans from which to start epidemics.

The most important malaria vector found was Anopheles albimanus with Anopheles pseudopunctipennis a possible secondary vector at the higher elevations. An interesting finding was that military guards at one frontier crossing were serving as a reservoir of malaria for the native population.

In the great majority of Central American cities pest mosquitoes of Culex and Aedes species breed in uncovered water storage reservoirs which owe their existence to adherence to old customs or on account of the general unreliability of the water supply. These present a considerable problem in the elimination of mosquito nuisances since it is seldom possible to enlist complete public cooperation in draining them periodically and the use of insecticides is not practicable.
Climatic factors in Central America influence the seasonal and overall production of mosquitoes to a greater degree than is sometimes realized. The torrential rains during the wet season overload drainage channels constructed to limit the extent of mosquito breeding waters and create pools or swampy areas which permit some mosquito development in spite of man's best efforts to prevent it. During the dry months early in the calendar year, temperature and humidity conditions on the Pacific slopes of Central America are such that mosquito breeding is greatly restricted. During this time adults of some Anopheles species, on the basis of laboratory data, survive only long enough to deposit eggs from which larvae hatch to maintain the race. The majority of adult female Anopheles probably do not survive sufficiently long to satisfy the minimum incubation period of the species of malaria parasites present.

Subsequent to the completion of sanitary surveys the Pan American Sanitary Bureau assumed supervisory charge of medical and sanitary programs in construction camps on highways being constructed under U. S. Public Roads Administration supervision. The majority of these were in Costa Rica and Nicaragua where malaria was an important factor in the reduction of labor efficiency.

The conditions for mosquito control in these construction camps are very similar to those which may be anticipated near new developments along the finished road.

In the organization of mosquito control for labor camps, the probable length of occupancy of the area is often the deciding factor in determining the nature and extent of operations to be conducted. Where the duration of the establishment is short or uncertain, extensive permanent drainage methods for the elimination of mosquito breeding can not be looked upon with favor. In Costa Rica at base camps drainage ditching and conventional fuel oil larvicide procedures alone were used to maintain excellent control of the mosquitoes and reduce malaria incidence to an insignificant figure. In lowland areas in this country before Anopheles mosquito control was inaugurated, malaria at various times accounted for from 12 to 40% of all time lost by American labor employed by contractors. Since malaria was one of the diseases for which financial compensation was received for the time lost in illness the amounts paid by insurance companies for time lost from this cause represented far more than the estimated costs of mosquito control in several places where it was not introduced.

In Nicaragua where large new camps were constructed on the Rama Road to the Atlantic which branches eastward from the Inter-American Highway not far from Lake Managua and Lake Nicaragua, practically full reliance for mosquito control and the prevention of malaria transmission was placed on DDT solutions in petroleum oil applied as larvicides and for laying down residual deposits for the destruction of adult mosquitoes in barracks and other buildings. This latter procedure was effective and had the great advantage of reducing flies and other insects commonly associated with man living under relatively primitive conditions. Until the advent of effective insecticidal sprays of the residual type the problem of dealing with a malaria reservoir among camp followers and itinerant vendors in the vicinity of labor camps or transportation centers was exceedingly difficult. The use of this type of insecticidal application on dwellings of this group of the population which was not subject to easy management was found to be more acceptable and effective than any other procedure.

The use of DDT in petroleum solvents met with equal success when used in some camps in Honduras.

In all work with labor groups, mosquito control could be carried on only within close limits of the camp operation. Because of the relatively free movement of workers into other areas active malaria cases and malaria carriers were continuously found which had to be treated with drugs. This is likely to be the situation
in the vicinity of stopping points along the highway in malarious regions for some years to come and emphasizes the need for adequate mosquito control at these points.

With the consideration of these desirable features of insecticide use for mosquito control in small or non-permanent installations along highways it may be of interest to consider some experience in the use of similar preparations as larvicides in the destruction of Simulium or Black Flies. This field of application may be considered an extension of mosquito larvicide work and it illustrates a number of the limitations which may arise from the general use of DDT.

In Guatemala between the highland and coastal highway routes paralleling the Pacific shore line lies a coffee producing area in which Simulium or Black Flies breed abundantly in swiftly flowing streams. This area slopes from an elevation of 5000-6000 feet down to 1000 feet in a distance of 20-25 miles. Several species of Simulium bite man and three species in the region are considered to be vectors of the filarial disease Onchocerciasis which can produce blindness. Until the advent of DDT, the larvae of these flies could not be combatted successfully.

After considerable experimental study, DDT emulsion concentrate, applied by means of saturated sawdust, was found to be a practical larvicide. Since Simulium larvae are found throughout the length of the numerous swiftly flowing small streams in the area, it was necessary to introduce the larvicide in highly concentrated form as near the sources of streams as practicable. The flow of water was usually sufficiently rapid that the period of contact of the larvicide at lethal concentration with the Simulium larvae was of relatively short duration. As the effect of the chemical was not prolonged, re-treatment of breeding streams was required at intervals of 1 to 3 weeks. Also, all streams over a relatively wide area had to be treated at the same time in order to reduce the number of adults infiltrating an area from close by to lay eggs and quickly neutralize the effect of the larvicide treatment.

These clear streams from the highlands are the primary sources of potable water used by the Indians. This water is also used as a source of power, for washing and processing coffee and finally for irrigation purposes. The application of concentrated larvicide at the source of these streams, while effective, raised the problems of (1) poisoning water supplies, (2) poisoning bees and beneficial insects which come to obtain water from the flumes leading to power plants in the very dry season, (3) the introduction of toxic materials into the processing of coffee beans and (4) the application of insecticide on plants through irrigation. In practice such treatments were found to destroy practically all predators associated with Simulium larvae including insects, crustaceans and fish. It was observed that the abandonment of such treatments after one season resulted in as much as a 25% increase in Simulium abundance over the number found in a comparable period in the previous year before larvicide operations were initiated. These findings illustrate some of the limitations in the selection and use of larvicides of this type.

Such experiences as these in Central America indicate briefly some of the situations to be encountered in the use of temporary measures for the destruction of mosquitoes and other diptera having aquatic immature stages.

Economic considerations and the difficulties encountered in the maintenance of semi-permanent drainage structures are at present making the American tropics a particularly fertile field for the application of the newer chemical methods for control of mosquitoes and other insects in limited areas.