

to assess the danger from this source. As shown by sporadic cases of Brill's disease in our larger cities we may assume that there may be a constant low level of infection in the population at large. In any case, experience during the last war has shown that epidemic typhus can be controlled even when in full stride. Extensive louse control measures can be postponed until there is evidence of marked increase in human louse infestation or increase in typhus itself.

Another important epidemic disease might follow an increase in the rat population—that is, bubonic plague. Where reservoirs of infection are known to exist as in some of our west-coast areas, transmission of the disease to man by rat fleas could occur on an epidemic scale. This would, in all probability, necessitate first an epidemic in the rat population. Rat control rather than insect control would be the most effective measure.

The question of the use of infectious agents in biological warfare and their possible relationships to insect-borne disease is obscured by the restriction of information by the armed forces. However, of the dozen or more disease agents that might be most effectively used, few would be primarily related to insect transmission. The enteric group such as cholera or typhoid

would be primarily water-borne—and only secondarily transmitted by "filth flies." Such forms as bubonic plague or even the rickettsial group might be used. Although these are primarily arthropod-transmitted under natural conditions, they can also infect via the respiratory tract and most probably would be disseminated as aerosols. Once established in the population, insect transmission might later be of importance and necessitate control.

One can go to the realm of fantasy in imagining what insects might possibly be used for nuisance value in a protracted attack. Less fanciful perhaps, might be the introduction of strains resistant to insecticides or new forms injurious to plants and livestock. If we consider the difficulty in handling large numbers of insects in this way I think we can assume they are low on the list of practical biological weapons.

Finally there is the additional point that epidemic patterns of some diseases may be changed by atomic warfare. Not only may there be greater destruction but if large groups are exposed to radiation an epidemic may run an extremely rapid course in a susceptible population with its general immunity lowered by radiation damage.

## MOSQUITO CONTROL ACTIVITIES OF THE COMMUNICABLE DISEASE CENTER, U. S. PUBLIC HEALTH SERVICE

GEORGE H. BRADLEY AND F. EARLE LYMAN

Federal Security Agency, Public Health Service, Communicable Disease Center, Atlanta, Ga.

The program for eradication of malaria from the continental United States continues to be the principal mosquito control activity of the Communicable Disease Center. This program was begun on July 1, 1947, and is carried on cooperatively with state health departments throughout the southeastern United States.

At the present time, the goal of the program—eradication of malaria as a disease of public health significance in this country—appears to be rapidly approaching.

Widespread use of DDT residual house spraying for malaria control was begun in this country in 1945, and approximately 700,000 house spray applications were

made in that year. The peak of activity was reached in 1948, when spray was applied in over 1,300,000 homes, in 360 counties of 13 states, at a cost in federal, state, and local funds of approximately \$5,000,000. The annual number of houses treated thereafter declined to about 1,000,000 in 1949, and to 842,000 in 1950. A six-year summary (1945-1950) of entomological evaluation of the program, based upon a total of 77,600 inspections of sprayed and unsprayed houses, indicates that 98.5 per cent of the sprayed houses were maintained free of *Anopheles quadrimaculatus*. In comparison, only 86.7 per cent of unsprayed houses were free of these mosquitoes; thus, control was approximately 90 per cent. There has been no indication of the development of resistance to DDT in *A. quadrimaculatus* such as has been encountered with houseflies, and also reported for some mosquitoes. In 1950 the percentage of sprayed houses kept free of *A. quadrimaculatus* was approximately the same as in 1945.

With the present low incidence of malaria in this country, it does not appear that the expenditure of further large sums on widespread malaria control activities will be necessary. In 1950, it is estimated that only 2,200 cases of the disease will be reported for the entire country as compared to 62,763 in 1945. Of 671 cases supposedly of malaria which were carefully appraised in southeastern states during 1950, only 26 proved to be parasite-positive, and of these 26, only 6 were judged to be new cases originating within the United States. In spite of this encouraging situation, however, it is deemed advisable to proceed with caution in terminating malaria control activities. We want to feel absolutely certain that the disease will not recrudescence. Hence, in accordance with the long-range plans set up at the start of the eradication program in 1947, and to fulfill the Malaria Eradication Criterion recently established by the National Malaria Society, the Communicable Disease Center is now organizing a Malaria Surveillance and Prevention Program. The National Malaria Society's

criterion is that "Malaria may be assumed to be no longer endemic in any given area when no primary indigenous case has occurred there for three years, if reporting and case finding are actively promoted and adequate investigations are carried out."

On the Surveillance and Prevention Program it is proposed, insofar as C.D.C. personnel are available and are needed to supplement state personnel, that epidemiologists, entomologists, and engineers will be assigned to work in cooperation with the health departments in the thirteen southeastern states to find and eliminate malaria wherever it may still be found, and take steps to prevent its reestablishment. The plan calls for the epidemiologist to investigate and appraise all regularly reported malaria cases, as well as others that may be uncovered by inquiry, and to determine the validity in each instance. Whenever a parasite-positive or clinically consistent case of malaria is located, appropriate treatment will be provided and the indicated anti-anopheline measures carried out. Other duties of the surveillance and prevention teams will include assistance in typhus control and other programs for the prevention of insect-borne diseases. The study by Mr. D. C. Thurman on mosquito dispersal in California, which will be reported on later at these meetings, is an example of this incidental work, as is a surveillance program being carried on in South Florida to detect any tendency for *Anopheles albimanus* to migrate northward.

Another phase of the antimalaria work of the Center is being carried on at three malaria investigation stations located in previously hyperendemic malarious areas at Manning, South Carolina; Newton, Georgia; and Helena, Arkansas. At these stations, close observations are being made on many factors related to the natural occurrence of malaria, in an attempt to detect as far in advance as possible any recrudescence of the disease, as well as to attempt to discover explanations for the present recession. Thick-film blood surveys are made periodically of all residents

in one of the study areas. In the two other areas, careful evaluations of all reported illnesses are made, and any person having clinical symptoms of malaria is carefully examined to determine if he actually has the disease. It may be of interest to this group to know that the last malaria epidemic of record in this country occurred in the vicinity of Manning, South Carolina, in 1944. A rapid decline in incidence followed, and no positive cases have been found in the area since February 1949.

Another activity of the Center which involves mosquitoes is concerned with encephalitis. Investigations are being carried on which are aimed at obtaining a more intimate knowledge of the role of mosquitoes in the over-all epidemiology of the disease, as well as the part played by other arthropods and the higher-animal reservoirs. The biologies and habits of potential mosquito vectors of the disease are being carefully studied in order to obtain information on which to base practical control procedures. Headquarters for these investigations in the East are at the Virus Laboratory of the Center in Montgomery, Alabama; in the Central States, at the Office of Midwestern CDC Services at Kansas City, Kansas; and in the far west the work is carried on cooperatively with the Hooper Foundation for Medical Research of the University of California, with headquarters at Bakersfield, California.

An increasingly important activity of the Center is related to the development of the water resources of the nation. One phase of this work is aimed at preventing the creation of conditions conducive to the production of mosquitoes on reservoirs and impoundments. In cooperation with the Corps of Engineers, Department of the Army, the Center during 1950 prepared survey reports covering recommended antimosquito measures for consideration in the construction of 46 reservoirs in 18 states. These bring to a total of 240 the number of reservoirs for which similar survey reports have been prepared since 1945.

Throughout the Missouri River Basin, mosquito problems in relation to impoundments and irrigation practices are being studied by a group of Center workers with headquarters at Kansas City. We are participating with other Federal and State agencies in making surveys to determine present and potential mosquito problems, and methods for their prevention, in connection with the work of the Federal Inter-Agency Water Resources Committee. At present, this work is under way in the northeast in the river basins of the New York-New England area, with headquarters at Boston, Massachusetts, and in the Arkansas-White-Red River basins, with headquarters at Little Rock, Arkansas.

At the Savannah, Georgia, Laboratory of the Center a variety of investigations on mosquitoes is under way. These have to do chiefly with the development of improved approaches to control. This work will be discussed by Dr. Archie Hess at a later session of this conference.

Any discussion of mosquito activities of the Center would not be complete at this time without some mention of the trend in present-day thinking in the Public Health Service relative to the interests of health agencies in mosquito control work. In a letter to regional and state health officials which discussed Service policy relating to disease vector and other mosquito control on water resources facilities, the Surgeon General states: "It is our conviction that pest mosquitoes should receive more attention from health authorities than they have in the past. Public health is something more than the absence of disease. Physical efficiency and comfort, on which mental equanimity depends to a substantial degree, may be seriously disturbed by the continued annoyance of pestiferous mosquitoes which may or may not have disease-transmitting potentialities."

It is also true, of course, that with the ever-increasing fund of our knowledge concerning the relation of mosquitoes to disease, many mosquitoes, traditionally of

importance from the standpoint of annoyance alone, are now coming to be labeled as potential transmitters of diseases. The distinction between "disease vector" and "pest" mosquitoes thus is fading. In view of these developments, health authorities may be expected to take an added interest in pest mosquito control programs.

By so doing, knowledge and effort of all parties concerned with mosquito control may be pooled, to the end that more pleasant as well as more healthful environmental conditions may be established throughout the country, with a concomitant promotion of greater national well-being.

## NAVY RESEARCH AND CONTROL OPERATIONS

JOHN M. HIRST

Lt. Commander, MSC, U. S. Navy, Jacksonville, Florida

The United States Navy is vitally interested in, and active in the study of problems related to insect disease vectors in general and mosquito control measures in particular. The necessary location of many Navy establishments is based on topographical features, geographical requirements, harbor facilities and other basic factors. Since most of these conditions which are valuable to naval operations are accompanied by positive ecological situations conducive to extensive insect breeding, it is elementary to understand the reasons for naval insect control interests.

Screening the research reports of studies completed or continued, the following were chosen as examples of Navy activity in problems which are important to us during these meetings.

During 1950, considerable information was prepared at the national Naval Medical Center, Bethesda, Maryland, and reported as "Observations on the Experimental Transmission of Japanese Encephalitis by Mosquitoes" and "The Propagation of Japanese Encephalitis Virus in the Mosquito by Parenteral Introduction and Serial Passage." At the same time conspicuous "Observations on the Pre-erythrocytic Stages of *Plasmodium relic-tum*, *P. cathermerium* and *P. gallinaceum* in various Birds" were conducted.

The taxonomy of the mosquitoes of certain strategic localities of the world has continued through 1950. "Mosquitoes of the Eastern Carolines and the Philippines" is now completed. A report of "Alaskan Mosquitoes" is in press. Navy taxonomists are now engaged in similar studies at the Naval Medical Research Unit #3 in Cairo, Egypt, where "Taxonomy of Mosquitoes of the Middle East" is in preparation.

Personnel at the Naval Medical Research Institute are also engaged in a study of the "Effects of Larval Population Density on Behavior of Adult Mosquitoes" and "Sulfonamides as Factors in Increasing Susceptibility of Mosquitoes to Parasitic Invasion (*Plasmodium gallinaceum*)."

The work in the Naval Medical Research Unit #3 in Cairo has developed very rapidly in the short time this Unit has been established. Reports on the achievements of this outstanding naval unit are being made available through popular and scientific publications. "Biology and Control of Houseflies in the Middle East" is a record of significance. Described in this report are the results of extensive studies of seasonal fly populations which exhibit the great importance of temperature to the definite annual population curve. In Cairo, too, rapid development of DDT resistance was