PAPERS AND PROCEEDINGS OF THE ANNUAL MEETING

OF THE AMERICAN MOSQUITO CONTROL ASSOCIATION HELD JOINTLY WITH THE ANNUAL MEETING OF THE UTAH MOSQUITO ABATEMENT ASSOCIATION, SALT LAKE CITY, MARCH 24–27, 1952

Part 2 of two parts

In this issue *Mosquito News* completes the publication of the papers which constitute the *Proceedings* of the Annual Meeting held at Salt Lake City, March 24–27, 1952, with the exception of papers the manuscripts of which were not turned in to the editor or which have not yet reached the editorial office in final form. These remaining papers will be published as soon as possible after their receipt.

The publication of all the Proceedings papers in the two issues of *Mosquito News* which followed the annual meeting, resulting as it did in two exceptionally large numbers of the *News,* was made possible by the fact that the registration and other fees charged at the Salt Lake City meeting were turned in to the AMCA treasury for that purpose.

Special notice should be given to one of the titles listed in the program, namely, "Mosquito Culture Techniques—Revised," by Helen Louise Trembley. This paper will appear separately in the near future as Bulletin Number 3 of the American Mosquito Control Association. It will probably comprise at least sixty pages; and includes not only descriptions of original work and comprehensive synopses and analyses of contributions by other workers, but also a complete annotated bibliography of all the published work in the field of mosquito rearing.

D.L.C.

MOSQUITO CONTROL MOVES FORWARD

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Nobody loves a mosquito. Were the public fully aware of the part mosquitoes play in causing sickness, poverty, and starvation, its dislike would turn to a deep and persistent hatred of these pests. This knowledge might bring about an international "Kill the Mosquito Week," the issuance of an "Anti-Mosquito Stamp," the organization of "Down the Mosquito" clubs, and the provision of adequate funds for research on all angles of the mosquito problem and for control operations.

Is mosquito control really moving forward? Many people are skeptical as to whether we are making material progress against this common enemy of man.

There is reason for this skepticism. Some communities are discouraged over

the necessity to continue expending funds year after year without being completely freed of the pests. The appearance of strains of mosquitoes resistant to insecticides is presenting a serious obstacle to mosquito control in some areas. This situation, in turn, is leading into another problem—possible ill effects from unnecessarily heavy or frequent applications of insecticides. Such careless operations might contaminate pastures, forage, and gardens and harm fish, wildlife, beneficial insects, and even man.

These interferences with progress in mosquito control, though annoying and impeding the work to some extent, are not regarded as unsurmountable. This is evident from the reports of progress both here and abroad.

Yesterday we spoke of keeping malaria under control. Today we talk of eradication. Thus far 70 to 80 million people in various parts of the world have been given some measure of protection from malaria. Already malaria transmission has been stopped in Chile, Italy, and Cyprus and the mosquito vectors greatly reduced in numbers. Extensive eradication campaigns have been started also in many other countries. DDT is changing the outlook of the work despite the development of resistance of some mosquitoes to it.

Venezuela, under the competent leadership of A. Gabaldon has radically cut down the principal vector *Anopheles darlingi* Root and *A. albimanus* Wied., through drainage and house spraying. Gabaldon (4) has reported that 70 per cent of the houses in the malaria zone were sprayed in 1951 and an effort is being made to treat the remainder of the houses mostly in isolated areas. The malaria death rate has fallen from a median of 112 in 1941–45 to 9 in 1949. Gabaldon states "These facts represent the greatest change Venezuela has ever had in her health conditions."

Brazil started a vigorous anti-malaria campaign in 1947, when 200,000 houses were sprayed. This program has grown so that in 1950 more than 3 million houses were treated and the malaria parasite rate in the regularly sprayed areas has been reduced to a low point. Seventeen million of Brazil's people are exposed to malaria transmitted by 5 different species of *Anopheles*. Forests containing bromeliads in which *Anopheles bellator* D. & K. breed are being cut down. According to Pinotti (11) 80 per cent of the houses received residual sprays and the National Malaria Service had a staff of 8,000 employees in 1951. In the national program 3,000 tons of DDT are applied annually. Some of this insecticide is now being formulated in Brazil.

Programs are going forward in other Latin-American countries including Argentina, Peru, The Guianas, Bolivia, Colombia, Ecuador, and Mexico. During the first half of 1949 Argentina had only 2,785 cases of malaria as compared with 300,000 during the same part of previous years. In Peru industrial employers, the National Agrarian Society, and the National Social Security Fund all work together to keep the parasite rate down, according to Williams and Stowman (16).

British Guiana's malaria campaign, begun in 1947, is an outstanding example of what can be done with residual sprays alone. *Anopheles darlingi,* the vector, has been eradicated from the treated areas. The entire operation directed by Giglioli (6), cost only 20 cents per capita, and the annual saving to that country has been enormous, both in money and suffering.

Italy, which for years carried a heavy malaria burden is now essentially free from the disease. This accomplishment followed years of background information on the *Anopheles maculipennis* Meig. group built up by Professor Missiroli and his associates and his conception and execution of a five-year plan for control by DDT residual spraying which was started in 1946. Since 1948 not a single death from malaria has been reported (Russell, 12). In Sardinia the intensive program to eradicate *Anopheles labranchiae* Falleroni started by the Rockefeller Foundation in 1946 has wiped out malaria and all but eradicated the mosquito carrier.

The systematic use of residual sprays and larvicides was begun in the Karpas Peninsula of Cyprus in 1946, especially for the control of *Anopheles superpictus* Grassi, the principal carrier. The other half of the island was treated during the next two years. The cost per capita was 22 cents. In 1950 the Cyprus Government announced that malaria had been eradicated from this island.

In 1942 when Greece had 2 million cases of malaria, she consumed more than one-fifth of the world's output of quinine. In 1946, UNRRA started a control program in that country including residual spraying of buildings and aerial application of larvicides. G. D. Belios (2) reports that malaria cases in urban areas have dropped from a mean annual rate of 1,000,000 per year before World War II to 10,000 in 1948–49. In 1950 there were only 50,000 malaria cases in the entire country and now the disease has been practically eradicated. As a result of the antimalarial campaign Lividas (9) estimates the annual saving at $20 million.

Williams and Stowman (16) have summarized the results of antimalarial work in India and Ceylon. Eradication projects were started in India in 1946. By using DDT residual sprays in houses and cattle sheds throughout the Kanara and Dharwar districts of Bombay the spleen index was reduced from 70 per cent to 7 per cent in three years. The plan is to extend the campaign over the entire malarious areas of the Province. In northern India, Terai, once so choked with malaria that half the villages were abandoned, is now getting this disease under control with residual sprays. Ceylon started to work on malaria control in 1945. After a field trial of DDT residual spraying the entire island was included in the 1946 campaign. According to the Ceylon minister of health almost two-thirds of the land was uncultivated due to malaria. One epidemic alone caused 80,000 deaths. The only vector of importance is *Anopheles culcifacies* Giles. DDT treatments repeated about every two months have brought malaria under complete control at a cost per capita of 22 cents a year. Large areas of land have now become available for cultivation and the people are better able to work them.

Thailand's success in largely eliminating malaria over part of the province of Chiengmai was made into a film entitled "The Ancient Curse." Before the eradication program was begun an average of about 2,200 people in the Serapee district were sick with the fever. The vector was found to be *Anopheles mimimus* Theo. Spraying operations were started in all dwellings and other buildings by the Thailand government with ECA financial and technical assistance. As a result, malaria transmission was largely stopped and prosperity increased in this rice-growing area. The WHO-UNICEF project in Thailand protected 40,000 persons in 1950 and the continued efforts of various groups gave malaria protection to 800,000 people in 1951. Plans are laid for a large expansion of the work this year and next year (World Health Organization (17)).

From Indonesia comes the report by D. R. Johnson and J. B. Wilson (8) that ten thousand acres of rich rice land in Java, deserted since the war because of endemic malaria, are being brought back into production after DDT spraying was begun by the Indonesian Ministry of Health and the Mutual Security Agency. An increased production of 4,400 tons of husked rice annually is anticipated from this operation.

Forward steps have been taken in Pakistan. Demonstration teams have applied residual sprays in houses occupied by a quarter of a million people, and the results have been convincing. It is reported that rice yields have increased 15 per cent in areas where well organized malaria control has been carried out.

In Afganistan and Iran much interest is being manifested in the control of *Anopheles* mosquitoes. This has been stimulated by the excellent results shown by residual spray operations made in selected malarious areas. In Afganistan a marked decline in the incidence of malaria has resulted in 1951 from residual spraying in demonstration areas.

Madagascar started a house-spraying program in 1949. About 1 million people have been given protection from malaria. DDT, BHC, and chlordane were combined in an emulsion used in some of the operations.

Malaria mosquitoes came to the island of Mauritius in 1860. Since that time it has been one of the worst malarious spots in the world. A vigorous campaign undertaken in 1945–46 under the direction of M. A. C. Dowling (3) and continued to date, has resulted in a spectacular reduction of malaria. For instance, hospital admissions dropped from 5,014 in 1942 to 196 in 1950. *Anopheles funestus* Giles, one of the chief vectors of malaria, and *Aedes aegypti* (L.) were practically eliminated. Since some *Anopheles gambiae* Giles still persisted, larviciding operations were begun late in 1950 as a supplementary measure.

In South Africa malaria carried by *Anopheles gambiae* and *A. funestus* became so severe that farmers began selling their lands and moving away. Seventy per cent of the labor suffered from malaria during the most critical harvest periods, and crops were lost. In 1945–46 house sprayings with DDT were begun, with the result that 42,000 square miles have been cleared of malaria. Bank and post office business in former malarious areas has been greatly accelerated. Most school absenteeism has disappeared. Farmers have extended their fields and production has been quadrupled, Williams and Stowman (16).

The serious consideration given to malaria problems in Africa and the plans laid for future antimalarial campaigns at the Malaria Conference (18) held in Kampala, Uganda, in November 1950, must be regarded as an important forward movement.

In Egypt DDT residual spraying was begun soon after World War II. In the successful campaign to eliminate an invasion of the Nile Valley by *Anopheles gambiae,* such spraying played an important role.

In our own country malaria has been on the decline for many years, Andrews (1), Russell (13). Since DDT has been used this decline has been accelerated. Today cases of malaria originating in the United States are rare. Probably the greatest factor in cutting down malaria during the last few years was the extensive residual-spray program carried out by the U. S. Public Health Service in cooperation with State health authorities.

We must not overlook the fact that practically all this rapid advance and the optimistic outlook for the future can be credited to mosquito control by the use of the new insecticides, particularly DDT, of which this country alone produced about 78 million pounds in 1950.

Although malaria-control operations are most needed and the results most striking, the value of controlling other mosquitoes should not be underestimated. The development of a protective vaccine against yellow fever has removed some of the urge for yellow-fever mosquito control; nevertheless the advances in mosquito control in South American countries a few years ago have been well maintained. The progress made in several of those countries has surpassed that observed in the United States. The recent outbreaks of jungle yellow fever in Central and South American countries, with little or no trouble in urban areas, indicate that *Aedes aegypti* (L.) control has been a big factor in preventing serious urban outbreaks. They also point to the need for more intensive efforts against this mosquito in Mexico and this country.

Progress in mosquito control in the United States has been notable. Not only has this advance been of a practical nature, but improvement is manifest in techniques, materials, equipment, and organization.

The appearance of strains of mosquitoes resistant to insecticides has caused everyone concerned to give greater attention to practices designed to eliminate mosquito breeding places. Furthermore it has stimulated basic research to solve the resistance problem. This problem is also of great importance in the fight against agricul-

tural and forest pests. This basic work will require time, but it is expected to yield results of great value.

Water control under conditions of heavy rainfall, irrigation, on salt marshes, and in connection with impoundments is receiving renewed interest. The value of water management in mosquito repression is well exemplified in the Tennessee Valley. Early impoundments in northern Alabama produced multitudes of malaria mosquitoes and much malaria. In 1934 blood surveys of people near the Wheeler Reservoir and Lake Wilson showed 25 to 65 per cent of the individuals positive for malaria. Lake-margin clearing, water-levels management, and shore-line maintenance were combined with limited use of larvicides and residual sprays. The tremendous chain of artificial lakes covering more than 600,000 acres with a 10,000-mile shore line, together with provision for flood control, navigation, and power, presents a serious mosquito-disease problem. Even under these conditions malaria is now entirely absent from the Tennessee Valley. Surveys made during the last two years showed not a single positive blood film. F. E. Gartrell (5) of the Tennessee Valley Authority has stated that 8,595 inspections of premises were made for *Anopheles quadrimaculatus* Say during 1950, and the average count was 1.7 females per inspection. This indicates the effectiveness of the antimosquito program.

The extensive soil and water conservation program throughout the country might well precipitate serious malaria problems. However, information acquired by the Tennessee Valley Authority and other agencies should enable us to meet these problems.

In the last few years we have witnessed great advances in insecticide development and improvement in application techniques. These have increased the effectiveness of the treatments, reduced the cost, and lessened the hazards to operators and to the public. The development in equipment for applying aerosols has been particularly outstanding.

The search for new insecticides for mosquito control is being continued by the Bureau of Entomology and Plant Quarantine, the Public Health Service, and several State agencies. Among the new materials found to be effective against mosquito larvae, the organic phosphorus compounds are the most promising. EPN and malathon are among the promising phosphorus compounds that will be explored further in mosquito control. Although most of these materials are highly toxic to animals and man, it is hoped that methods for safe use can be found, and that mosquitoes will not develop resistance to them so rapidly as to the chlorinated hydrocarbons.

In the Alaskan research it was shown that the application of 0.3 to 0.7 pound of DDT per acre to the breeding areas gave a high degree of larval control for two seasons. The DDT residue remaining in a 100-square-mile treated area reduced larval abundance a year later by at least 95 per cent. The Public Health Service has demonstrated a remarkably long-lasting residual effect from dieldrin applied as a prehatch treatment.

Several thousand compounds have been tested as synergists to increase the efficacy of DDT against resistant-mosquito larvae. However, none of them increased the effectiveness of DDT appreciably.

Research on repellents conducted by industry and State and Federal agencies has made distinct progress. The effectiveness and practicability of clothing treatments to supplement skin treatments with standard insect repellents, were investigated in Alaska by the Bureau of Entomology and Plant Quarantine and the Department of Defense. A material, designated M-1960, was found to prevent mosquito biting through clothing for about a week when uniforms were dipped in 5 per cent emulsions of this material. The formula is one developed at Orlando as a multipurpose clothing repellent to protect military personnel from attack by mosquitoes, ticks, mites, and fleas. The concentrate consists of 30 parts benzyl benzoate, 30 parts *N* butyl acetanilide, 3- parts 2-butyl-2-ethyl-1, 3-propanediol and 10 parts emulsifier.

Industrial and Engineering Chemistry (7) reported that D. E. Piper, R. H. Hall and G. F. Wright, University of Toronto, had encouraging results in preliminary tests with a number of compounds as repellents. Among these were *d,l*-benzyl lactate; 70% 2-methyl-1-phenyl-1, 2-propanediol + 30% ethyl mandelate; 1-hydroxy-1-phenyl-2-propanone; 1-methyl-1-phenyl-1, 2-propanediol; ethyl mandelate.

The organization of new mosquito control districts is always encouraging, as it shows that interest in nuisance abatement is spreading. Two new districts have been created in Virginia in 1951. In Utah a South Salt Lake County Mosquito Control District has been set up and another district to include Davis County is being organized. No doubt there are a number of other recently established abatement districts of which I do not have knowledge.

The important bearing that studies of mosquito biology, distribution, and taxonomy have on control work is not always fully recognized. In the study of the life history and habits of a mosquito a means of rearing it in the laboratory must be developed. Much has been done in this direction, as indicated by the excellent summary of mosquito-culture techniques by Helen Louise Trembley (14), to be presented at this meeting. She reports that 43 species have now been successfully colonized, 17 of them since 1944.

It is surprising how many new species are continually being turned up. In 1951, for instance, 47 new species, 2 subspecies and 1 genus, were described. These included 11 *Aedes,* 2 *Anopheles,* and 20 *Culex*. Advances have also been made in determining whether closely related forms, such as those in the *Culex pipens* L. complex, are really distinct species, subspecies, or simply strains.

Information of value on distribution is being accumulated in many areas. Perhaps the most extensive study along this line is that being carried on by C. R. Twinn (15) and associates in the Arctic regions of Canada.

Knowledge of flight habits is of great importance in mosquito control. Notable advances in this direction, especially through the use of radioactive isotopes, have been reported in California with *Culex nigromaculus* (Ludl.) and in Florida by Mulrennan (10) with *Aedes taeniorhynchus* (Wied.). In the Florida tests with *A. taeniorhynchus* a dispersion over a 20-mile area occurred within 3 days after liberation.

Contributions to knowledge of the biology, habits, and ecology of numerous species have been made by many workers. Undoubtedly, investigations such as are now being carried on with *Aedes taeniorhynchus* by Mulrennan (10) and associates in Florida will be of material aid in indicating ways of strengthening our defense against these pests.

A review of the mosquito control situation from a world viewpoint clearly shows a forward movement. The application of known methods of mosquito control to malaria problems is now freeing millions of people from this, the world's most debilitating disease. It is also greatly lessening the hazards of those terrifying diseases, yellow fever, encephalitis, and filariasis. Relief from annoyance and economic losses by pest mosquitoes is also paying substantial dividends. However, the job is far from finished. Years of effort will be required to relieve many parts of the world from the distressing effects of mosquito borne diseases. The efficiency, speed, and perhaps the ultimate success of this effort will depend on a continued flow of new information from basic and applied research. Much needed information is forthcoming, the difficulties encountered are being overcome, and the outlook for the future is good.

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THE PLUMBER'S NIGHTMARE, KING SIZE

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During the last few years insecticidal fogs have been used extensively for the control of adult mosquitoes. Interest in this method of control has stimulated the initiative of many workers, all seeking the same end result. This search has been directed toward an efficient, low-cost fog generator that could cope with the many variables encountered in field operations, operating personnel and available materials. The fog generator described in this paper is Consolidated Mosquito Abatement District's contribution to that search. The Plumber's Nightmare, King Size, has been field-tested and is presented with pride by a group of experienced foggers.

The Plumber's Nightmare is a product of limited income and unlimited mosquito production (Raley, 1947). More odds and ends from the plumber's scrap pile, war-surplus material and discarded vehicle parts than new parts have been used in developing this fog generator. William Miller, of the Sutter-Yuba Mosquito Abatement District, of California, deserves full credit for his determination and his ability to find necessary parts at little or no cost. The mosquitoes were a constant irritating reminder that needled us into many hours of scorched-finger labor.

As the Plumber's Nightmare gained favor as a vehicle exhaust generator, modifications were assembled in many parts of the world. Ralph Crowe expanded its use by building a portable unit for fogging the inside of buildings on Guam (Crowe, 1948). A. L. Fleming, at Sutter-Yuba, met the challenge by modifying the original (Fleming, 1950). This unit is perhaps the most efficient of any fog generator for use on a vehicle. Fleming's modification eliminated practically all "drag" on the truck motor and nearly doubled the rate of material discharge. These improvements made it possible to operate the vehicle in a higher gear, saving both time