PROCEEDINGS AND PAPERS

OF THE

FOURTEENTH ANNUAL CONFERENCE
OF THE
CALIFORNIA MOSQUITO CONTROL ASSOCIATION

Held at Agriculture Hall,
University of California,
Berkeley, California
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Note: On account of war conditions, the annual conferences in 1942 and 1943 were omitted. The Thirteenth Annual Conference was held February 28 - 29, 1944.

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The Fourteenth Annual Meeting of the California Mosquito Control Association was called to order at 9:30 a.m., Monday, February 25, 1946, in Room 113, Agriculture Hall, University of California, Berkeley, California, by President W. P. Menefee.

President Menefee: This meeting of the California Mosquito Control Association will please come to order. I will ask Assistant Dean Stanley B. Freeborn of the College of Agriculture to give his address of welcome.

Dr. Freeborn: I think it is somewhat queer that from time to time I am asked to open meetings being held here on the campus by various groups about whose work I know practically nothing, and they give me an hour or so in which I have to hold forth. Then along comes a mosquito abatement conference and, though I do know something about mosquitoes, they let me make an opening address and give me five minutes. However, I promise you I am going to take more than five minutes later on, though at this time I will be very brief. All through the conference, whenever I can horn in, I'll be doing so because there is nothing closer to my heart than mosquito lore and mosquito control. I am not going to take time now to say anything about mosquitoes or the importance of the work. You know that better than I do.

The one thing in the way of welcome I would like to leave with you is just the manner of approach we had this year about holding the meeting here. It was extremely gratifying to us to have the program chairman call and ask "What days can we have the meeting this year?" This is the way we like to have it. We like to have you think of this institution as headquarters for the work that is going on not only in California but in some of our neighboring states. You are always welcome here and if there is anything we can do for you in order to make your stay more pleasant or instructive, just let us know and we will be only too happy to oblige in any way we can.

There used to be a day at the University when we had possibly three people who were vitally interested in mosquitoes. Now we are flooded with people who are mosquito experts. For example, recent additions to our staff include Hoddman, Douglas and Bailey, who have come to us with a long background of experience in mosquito control in various areas. We are entomologically speaking, just "lousy" with experts now. In agriculture, in public health, in entomology, and in various other phases we can be of assistance to you. The university is here to serve you and to serve the public.

I am asked to turn this meeting over to Harold Gray at this point, so just let me say I hope you have a grand time here.

Mr. Gray: Thank you, Dean Freeborn. We are always glad to be around here -- even those of us who are here a good part of the time.

We are now to hear the report of our Secretary-Treasurer, E. Chester Robinson.

Mr. Robinson: The Association is in excellent financial condition, having cash on hand as of February 23, 1946, the sum of $420.9?. I present this report of receipts and expenditures.

Mr. Gray: Thank you, Chester. This detailed report will be published as a supplement to the Proceedings of this Conference

The next matter of business seems to be the appointment of certain committees.

Mr. Menefee: The Nominating Committee is to be composed of Emerick, Campbell and Gray.

Geib, Gray, Mapes, Murphy and Pangborn are asked to serve on the Ways and Means Committee.

These committees are scheduled to report at 1:30 today.

Mr. Gray: There are two or three things I would like to mention at this time. I ask each one of you to be sure to register. I also call attention to the fact that we have a few copies of the Proceedings of the last Conference. They are available if you would like to have them and will see the Secretary-Treasurer. I will leave them here on the desk.

The first paper we are to have is by a man whom I think has trained and taught most of us on the Pacific Coast. He is responsible for more mosquito work than anybody else. He and Col. Bradley are the grand old men in this field of work. I take great pleasure in presenting Professor William B. Herms.

Prof Herms: Before presenting my paper I wish to remark that the first information (verbal and confidential) concerning an extraordinarily potent (almost miraculous) insecticide known as Gesarol was received by us at the Army School where I was stationed at the time early in 1943. So far as I am aware the first information (restricted) for use in instruction was dated sometime in March 1944. Many of you know that Herms' and Gray's revised (1944) edition of Mosquito Control was held up several months under censorship because of a brief inclusion of some experimental data (our own) concerning the use of DDT as the insecticide had then become "popularly" known. Our work had been done on mosquito larvae and pupae.

It was not until October 1943 that some highly purified DDT became available to me for experimental work and my tests with minute dosages began after my release from the Army and my return to the University of California.

SOME COMPARATIVE LABORATORY TESTS WITH MINUTE DOSAGES OF DDT, 666 AND DDD ON MOSQUITO LARVAE AND PUPAE

By William B. Herms,*
University of California, Berkeley

While conducting some exploratory laboratory tests with DDT (dichloro-diphenyl-trichloroethane) on the immature stages of mosquitoes during December of 1943 the author was impressed with the high toxicity of minute dosages of this chemical. The proceedure consisted of placing ten full grown (fourth instar) larvae and ten pupae of Culex tarsalis in a small tumbler containing 50 cc. of tap water and then adding DDT (purified 98+%) dissolved in so-called absolute alcohol so as to produce when added to tap water dilutions of DDT ranging from one million to six hundred millions, i.e., 1 part DDT to one-, two-, five-, ten-, thirty-, fifty-, one hundred-, two hundred-, and six hundred million parts of water. Dilutions of one part per million killed all larvae in about one hour; dilutions of two millions killed in less than one and a half hours; pupae were killed within twelve hours. Weaker dilutions required progressively longer time to kill the larvae and did not kill all of the pupae; however, as the adult mosquitoes emerged from surviving pupae most of them died on the surface of the water. Thus a dilution of one part DDT to 30,000,000 parts of water killed all the larvae in about fifty hours; two of the ten pupae were dead in 72 hours, however, eight adults had emerged, six of them dead on the surface, and two were apparently normal.

At dilutions of fifty millions, eight out of ten larvae were killed in 72 hours, two succeeded in pupating and at the end of 96 hours there were no pupae left, twelve adults having emerged normally and were alive, thus indicating no ill effect on the adults or pupae at this concentration. Though concentrations as low as one part DDT to 600,000,000 parts of water were used in these tests the results were inconclusive. In all cases third and fourth instar larvae and pupae similarly confined in receptacles of tap water but not dosed with DDT carried on normally. Room conditions varied little from 70° F and 50% relative humidity.

It was furthermore observed while conducting these early tests that sufficient DDT residue remained in emptied containers having had a dilution of one part per million to kill all fresh larvae added to refilled (fresh tap water) containers in about one and a half hours. A second change of fresh tap water resulted likewise in the death of larvae in less than eighteen hours. Adult mosquitoes placed in a dry jar which had previously contained a dilution of one part DDT to 6,000,000 parts water were killed on contact with the walls of the glass in 24 hours, the jar having been dry by evaporation 57 days.

Further tests of a preliminary nature were made at intervals during 1944 and early 1945 using various species of culicines particularly Culiseta inornata and Culiseta incidens. No difference in species reaction to either DDT or 666 (referred to below) was

*Professor of Parasitology and Lecturer in Tropical Medicine observed hence the several species listed were used indiscriminately in the earlier tests. Third instar larvae are killed more quickly than the fourth as are also the larvae of smaller species.

In June 1945 the author secured some samples of hexachloro cyclohexane, a chemical known as 666 ($C_6 H_6 Cl_6$), said to have been first reported by Michael Faraday in 1825. This chemical was similarly tested by me with rather interesting results particularly in the fact that the two isomers tested had decidedly different toxic effects. Thus a trace of gamma 666 (unpurified) dissolved in absolute alcohol, dilutión undetermined, stirred into 50 cc. of tap water with ten larvae killed all in about one hour. A similar dilution (unknown) in xylol killed all larvae in about twenty-two hours. A similar treatment with a trace of alcohol or xylol alone did not injure the larvae. Dosages with similar dilution of the delta isomer in either xylol or alcohol proved ineffective after 72 hours of exposure. No further work was done with this latter isomer. Later tests were made with more highly purified (80%) gamma 666 with rather similar results and discontinued later in favor of the more highly purified (90+%) material as set forth below.

The above described crude preliminary tests led to a series of comparative and simultaneous tests. In these tests purified DDT (98 %) and purified 666 gamma (90-%) were used, and in addition a few tests with purified DDD (dichloro-diphenyl-dichloroethane also referred to as TDE*). Stock solutions of the various chemicals were made up in absolute alcohol to constitute a dilution of .01 mg. per cc. As with the early tests, small glass tumblers were used containing 50 cc. of tap water; fourth instar larvae and pupae (ten of each in separate containers) of Culiseta incidens were tested. Checks were run in tap water and dilutions of alcohol alone. (See discussion) The dilutions were made by stock solution in sufficient quantity (using micro-pipette) to the tap water containing the mosquito larvae or pupae to make the desired dilution. Obviously the dilutions are only approximate due to several factors, such as the degree of purity of the chemical, the uncertain accuracy of measurement of both tap water and solution. Larvae eventually after falling and rising several times dropped to the bottom when overcome by the solution, but continued to squirm and jerk for several minutes. They were recorded as down only when they did not rise on tapping the glass. They were recorded dead after all movement had apparently ceased. Air bubbles at the opening of the siphon frequently caused larvae to rise. Pupae usually died at the surface, very few sinking to the bottom until later. Pupae were recorded as dead when no movement was observed.

*TDE, 1, 1-Dichloro-2, 2-bis (p-chlorophenyl)ethane, as an anopheline larvicide, by Deonier and Jones. Science Jan. 4, 1946. pp. 13-14.

TABLE 1.
A Typical Series showing Some Comparative Tests with Minute Dosages of DDT, 666, and DDD on Larvae (Fourth Instar) and Pupae of Culiseta incidens. Room Temperature 70°F; RH, 50%

Approximate dilution in tap water	DDT (98%) LARVAE 90% Down	DDT (98%) PUPAE 100% Dead	DDT (98%) 100% Dead	666 _ 90%) LARVAE 90% Down	666 _ 90%) LARVAE 100% Dead	666 _ 90%) PUPAE 100% Dead	DDD (99%) LARVAE 90% Down	DDD (99%) LARVAE 100% Dead	DDD (99%) PUPAE 100% Dead
1,000,000	25 min.	60 min.	6 hrs.	20 min.	35 min.	4 1/4 hrs.	30 min.	65 min.	7 1/2 hrs.
2,000,000	35 "	75 "	9 1/2 "	50 "	85 "	8 1/4 "	35 "	150 "	no test
3,000,000	65 "	115 "	9 1/2 "	80 "	135 "	7 1/2 "	55 "	150 "	"
4,000,000	80 "	135 "	30 "	100 "	140 "	15 "	60 "	180 "	"
5,000,000	100 "	195 "	30 "	105 "	195 "	48 "	85 "	120 "	32 hrs.
10,000,000	450 "		29 "	1470 "		55 "			
20,000,000	650 "		65 "			70 "			

DISCUSSION

Because of the wide variation in results obtained in tests with dilutions weaker than 1 part per 20,000,000 these are not included in Table 1. Considerable additional work will be necessary with weaker dilutions although many tests were made by the author with dilutions of 1 part per 30,000,000: 1 to 50,000,000; 1 to 100,000,000; and 1 to 150,000,000. The results were too scattered and too uncertain to permit of proper analysis in this brief paper.

The series reported in Table 1 was replicated many times with fairly even results. It would appear that a dilution of DDT down to 1 part per 20,000,000 for fourth instar larvae and pupae is fairly dependable. A dilution of 666 of 1 part per 10,000,000 for larvae and 1 part per 20,000,000 for pupae seems also to be dependable. It is interesting to note that 666 has considerable pupacidal value. DDD as far as the tests have been done gives about the same results as DDT. The true toxic efficiency of the larvicides is not reflected in Table 1 for dilutions under 1 part per 5,000,000, since the alcohol alone in dilutions stronger than this has lethal effect on both larvae and pupae though at a slower rate. Further work is in progress and the data presented in this paper are in the nature of a progress report.

Mr. Gray: Thank you, Professor Herms.

We will have a discussion of these matters later after this first series of papers has been presented.

We are now to hear from Dr. Stewart on "The Use of DDT in Controlling Household Insect Pests."

THE USE OF DDT IN CONTROLLING HOUSEHOLD INSECT PESTS

By M. A. Stewart
University of California, Berkeley

The widespread publicity that has been given to DDT and its efficiency as an insecticide has resulted in intense interest in and demand for this material for the control of household, and other, insect pests. Consequently, mosquito abatement officials, as well as others engaged in the control of noxious insects, are bombarded with requests for information on the use of this new insecticide and therefore must be in a position to offer sound advice relative to its appropriate use and proper safety precautions.

DDT acts as both a contact and stomach poison but it does not kill all kinds of insects. Against those insects which it does kill, its action is slower than that of some of our most common insecticides. Its most unusual property is its prolonged residual effect.

DDT has been released for public use in a great variety of forms and these numerous preparations contain DDT in varying amounts. Therefore, the labels on the containers should be read carefully in order to ascertain that the proprietary materials contain sufficient amounts of DDT to be effective.

Oil solutions of DDT, employed as residual sprays, must contain at least five per cent DDT to be effective. If the manufacturer's label indicates that a DDT isomer or by-product is the active ingredient, an eight to ten per cent solution is necessary to obtain satisfactory results. Some of the solvents used in oil solutions of DDT are inflammable. Therefore, precautions should be taken against the danger of fire. Also, some of these solvents may damage furniture and floors.

A number of dry mixtures of DDT are available for use as dusts. For household insects, these dusts should contain no less than ten per cent DDT.

Aqueous suspensions are made from DDT powder containing a chemical which permits the DDT particles to be suspended readily in water. Such suspensions should contain five per cent DDT. They present no fire hazard, but they leave a white spotting on dark surfaces and window glass.

Emulsions are made from DDT plus an organic solvent and an emulsifier. From these emulsions residual sprays containing five per cent or more DDT may be prepared.

Paints containing DDT have been developed, but no recommendation as to their effectiveness can be made at the present time.

When residual sprays are employed, complete coverage of the sprayed surfaces must be effected. This may be done easily and successfully by means of a small power sprayer or a paint brush. One should not permit oil solutions or emulsions of DDT to remain in the sprayers because they will rust the spray tanks, rot the gaskets and plug the hose and nozzle.

Dust guns are used when DDT is employed as a powder.

In order to avoid spotting when DDT sprays are used, varnished floors and dark linoleum should be covered with newspapers and darked stained furniture should be covered. Shades may be pulled down to prevent spotting of window glass. Light wall surfaces should be wiped with a clean, dry cloth before spraying to remove the dust. Otherwise, the droplets of spray will collect particles of dust and leave a dirtspotted wall. Some wallpapers, especially those of certain shades of blue or green, may be spotted by DDT sprays. Calcimined surfaces should not be sprayed, because the spray may cause the calcimine to run.

The following household insects may be successfully controlled with DDT. Spraying or painting the resting places of houseflies with a five per cent DDT solution, emulsion or suspension will give excellent results and the residue will remain effective for three months or longer under average conditions.

Adult mosquitoes within buildings may be controlled by spraying the wall surfaces and ceilings, especially the dark corners, portions of walls behind pictures and furniture and other undisturbed places. Cockroaches may be killed by blowing ten per cent DDT dust into their hiding places or by spraying such places with a five per cent spray. After such treatment no marked results should be expected for at least a week. Bedbugs are killed with most remarkable success after forty-eight hours exposure to a five per cent DDT spray applied to mattresses and bedsteads and, in heavy infestations, to the cracks and crevices in which these insects hide by day. A ten per cent DDT powder or a five per cent spray gives excellent control of fleas. A single application of dust may be effective for as long as eighty days. Most dogs, but not cats, infested with fleas may be dusted with a ten per cent DDT powder. DDT is effective against some species of ants. A five per cent spray or a ten per cent dust is applied over the surfaces of predetermined points of entrance into households. DDT dust may be blown into ant nests when they can be located, but sprays are not effective in the treatment of nests because they merely serve to repel the ants. Silverfish may be controlled with DDT by employing the same techniques as used against cochroaches.

It must be remembered always that DDT is a poisonious material. It should be used carefully and with adequate safety precautions. Furthermore, it must be recognized that many of the solvents, as well as the DDT itself, are toxic. One should always avoid permitting oil solutions from coming in contact with the skin because DDT in oil is rapidly absorbed directly through the skin. If clothing becomes wet with a DDT solution it should be removed immediatèly. Whenever oil solutions of DDT come in contact with the skin, it should be promptly and thoroughly washed with warm water and soap. DDT mixtures should be prepared out-of-doors or in specially ventilated rooms. Great care should be exercised to avoid contamination of food with any type of DDT preparation. If DDT is accidentally swallowed, the patient should drink mustard water immediately to cause vomiting, and a physician should be seen at once. Mustard water is prepared by dissolving one tablespoonful of mustard in a glass of water. One should not allow DDT dusts to remain on the skin and in using such dusts excessive inhalation should be avoided. Adequate precautions must be taken to prevent mistaking stored DDT powder for foodstuffs. Persons applying DDT in appreciable quantities should wear neoprene gloves, goggles and an appropriate respirator.

Mr. Gray: Thank you, Dr. Stewart, for this very excellent and well organized paper. I notice you use the method of the old darky preacher who said "First I tells them what I'se goin' to tell 'em; then I tells 'em; and then I tells 'em what I told 'em."

At the session this evening (at 7:30) there will be opportunity for a general discussion of our problems. At that meeting we will have some of the experts here try to answer your questions. If, as we go along today, you have questions that come to mind, or if you already have problems you would like to hear discussed, please write them out on a piece of paper and leave them in the box we have here. The answers will be assigned to those considered to be the most expert along that particular line.

H. H. Stage from Washington, D. C., expected to be here and at this time was to have given a paper on "DDT Offers Two New Methods for Controlling Anopheline Mosquitoes." However, Harry was unexpectedly called to South America, so his paper will be read by C. M. Gjullin, of the U. S. Bureau of Entomology and Plant Quarantine, whom we are most happy to welcome here again from Portland, Oregon.

(Note: Mr. Stage's paper was illustrated by Kodachrome Slides.)

DDT OFFERS TWO NEW METHODS FOR CONTROLLING ANOPHELINE MOSQUITOES

By H. H. Stage
Bureau of Entomology and Plant Quarantine
Agricultural Research Administration
U. S. Department of Agriculture

The development of DDT as an agent for controlling mosquitoes has suggested two new methods which are particularly effective in destroying those species that carry malaria. Early in 1943, only a few months after the first sample of DDT had reached the United States, research conducted at the Orlando, Fla., laboratory of the Bureau of Entomology and Plant Quarantine demonstrated that at last a chemical was at hand which, when sprayed on the walls and ceilings of buildings, would leave a residue that would be continuouslyactive in killing the mosquitoes that rested on it. After three years of accelerated research we believe that the greatest promise for DDT in malaria control is its use as a residual spray.

The second new method offered by DDT is the use of aircraft to apply an insecticide against both adult and larval anopheline populations in one treatment. This is the first time in the history of medical entomology that an insecticide has killed adult mosquitoes over large areas when applied by means of aircraft.

The idea of reducing the number of anopheline mosquitoes by spraying the interior of dwellings is not new. Conspicuous results have been reported by workers in Africa and India. However, these pioneers used space sprays of pyrethrum at weekly intervals, whereas by properly using DDT on the diurnal resting places of the adult we can get better results with treatments applied at three to twelve-month intervals.

The Orlando entomologists first obtained a certain amount of preliminary information in the laboratory. This information indicated that DDT was effective against adults of Anopheles quadrimaculatus Say and Aedes aegypti (L.), when applied as a residual spray on wooden boxes and canvas cages at rates of 10 to 400 mg. per square foot. Comparative tests showed a water emulsion and a water suspension of DDT to be equally effective on wood, and both slightly superior to a DDT-Kerosene spray. Mosquitoes resting on a DDT-treated surface acquired a lethal dose within a few minutes and began dying 2 to 4 hours after exposure. In contrast with other common insecticides, DDT kills more rapidly at low temperatures than at high temperatures.

Exposure of mosquitoes for 24 hours to residue of 100 mg. per square foot or more resulted in the death of all mosquitoes for 32 weeks after the treatment. Sunlight had a deleterious effect on the chemical, but the loss in toxicity occured slowly, for a box treated with a deposit of 50 mg. and exposed to sunlight continued to kill all mosquitoes introduced into it for 24 weeks. DDT residues were highly toxic on unpainted surfaces and on surfaces covered with two coats of cold water-casein paint that had been applied less than two weeks before. The residue was much less effective, however, on surfaces recently painted with oil paint.

DDT activated the mosquitoes that rested on treated surfaces and caused the insects to fly, but not before most of them had obtained a lethal dose.

Backed with this information, James B. Gahan, B. V. Travis, Fred A. Morton, and Arthur W. Lindquist reduced the number of mosquitoes remaining in buildings in the vicinity of Tallahassee, Fla., and Stuttgart, Ark., during August 1943. In Arkansas the work was done in cooperation with John E. Taylor and L. H. Biggs, of the U. S. Public Health Service, and employees of the Arkansas State Board of Health.

One test in the stuttgart area demonstrated the effectiveness of DDT residues against Psorophora mosquitoes. Three walls of a dairy barn were treated with a water suspension containing 1 per cent of DDT. The doors at opposite ends of the barn were left open, and a 40-watt electric bulb was lighted during the night to attract mosquitoes into the building. After being attracted to the light, they rested on the treated walls. Within 2 days approximately 50,000 dead Psorophora mosquitoes were found on the floor. No doubt others flew out of the building and died elsewhere.

A more important large-scale test was conducted in a large rice-growing section near Stuttgart during the mosquito season of 1944. In this test DDT residual sprays were applied to the inside walls and ceilings of nearly every building in two 9-square-mile areas to determine the duration of effectiveness against Anopheles quadrimaculatus of a single application and to ascertain whether the general population of this species could be reduced by using this method of control. The spraying was finished in June, and records were maintained until October. For more than 3 months the treatment remained effective, and it reduced the adult-mosquito population in the buildings by over 90 per cent and the larval population in the rice fields over 55 per cent.

During the mosquito season of 1945 Mr. Gahan conducted still other tests with DDT as a residual spray, this time against Anopheles pseudopunctipennis breeding in rice fields in the State of

Morelos, Mexico. In this instance he sprayed a five per cent DDT emulsion onto the interior of all the native houses in two villages, each of which contained about 400 homes. These houses were made of adobe, cornstalks, or rice-straw walls with thatched, tile or straw roofs. In addition to over 99 per cent reduction of these mosquitoes practically all infestations of bedbugs and fleas in the buildings were eliminated. Fly, cockroach, and scorpion populations were also greatly reduced. The populations of mosquito larvae occurring in rice fields near one of the treated villages were reduced over 80 per cent as compared with those found in other rice fields surrounding an untreated village nearby.

When I visited the area early in October 1945, about 5 months after the first treatments had been applied, I was amazed to see how few mosquitoes could be found in the houses and rice fields in the treated areas compared with those observed in houses and rice fields in untreated areas.

Working with two important malaria vectors and in houses built of a variety of materials, Mr. Gahan has demonstrated the practicability of reducing anopheline populations with one DDT residual spraying during the breeding season.

Entomologists are now using DDT sprays for reducing anopheline populations in several parts of the world, such as in the southern United States, Central America, India, the Mediterranean area, and on Pacific Islands.

The effectiveness of DDT sprays against both the adult and larvae of anopheline mosquitoes was determined early in 1943 by E. F. Knipling, A. W. Lindquist, B. V. Travis, C. C. Deonier, C. B. Wisecup, A. H. Madden and others of the Orlando laboratory. After preliminary tests in Florida with Cub and Stearman type planes had shown the technique to be promising, additional tests using larger planes over larger areas were made in Florida and Panama in cooperation with the Army and Navy. In January and February 1945 four of us from the Bureau of Entomology and Plant Quarantine aided the Army in a series of tests in which a C-47 (capacity load 800 gallons) and a B-25 (capacity load 525 gallons) plane dispersed several DDT sprays at rates from o.4 to 0.8 pound of DDT per acre. From 4 to 8 quarts of liquid were applied per acre over heavy jungle foliage, and within 24 hours a 99 per cent reduction of adult mosquitoes was obtained. Some idea of the reduction within one of the test areas, which was a mile long and one-half mile wide, can be gained by the counts made in a baited horse trap. An estimated 10,000 mosquitoes of several species were captured in the trap the night before the area was treated. They were released at daylight, and within a few minutes the B-25 began the treatment 200 feet overhead. Twenty-four hours later the same trap caught but 1 mosquito, and 48 hours later 3 were counted. The number then rose gradually each day until over 200 per day were caught after 2 weeks.

In another instance 15,000 adults, mostly <u>Anopheles albimanus</u> (Wied.), were caught in a horse trap during one night, and nearby in the waters of Gatun Lake an average of about 12 anopheline larvae were taken per dip in 200 dips. Twenty-four hours after treatment 86 mosquitoes were caught in the horse trap and not a single anopheline larva could be found in the lake -- a reduction of 99 per cent of the adults and 100 per cent of the larvae with one treatment.

Since these tests were made, the Army and the Navy have depopulated of mosquitoes many malaria- and dengue-infested islands in the Pacific.

I believe the time has arrived when these methods should now be put under more difficult tests, i.e., species eradication on islands such as Puerto Rico and Sardina, and in small countries such as El Salvador and Ecquador.

Mr. Gray: Thank you very much, Mr. Giullin. We have a few minutes we can devote to questions at this time or, if you prefer, write them out for the evening session and put them in the question box. I might add that I have just received the first question for the box.

We have with us today a gentleman who is here from Atlanta, Georgia. He is with the U. S. Public Health Service there. He is one of our very earliest entomologists in this field. Col. Bradley.

Col. Bradley: Before I give my paper, let me extend greetings from Mr. Hollis and his MCWA staff in Atlanta. California is quite a ways from Atlanta but we haven't felt far away because we have used folks from here in our work -- Freeborn, for instance. And "Mosquito Control" by Herms and Gray.

THE USE OF DDT ON THE MALARIA CONTROL IN WAR AREAS PROGRAM

By
G. H. Bradley, Senior Entomologist (R)
U. S. Public Health Service

The principal method for the control of malaria utilized on the Malaria Control in War Areas program is that of attacking the mosquito vector of the disease. Although highly satisfactory results have been obtained by using the standard mosquito control practices together with a rather rigid system of entomological surveillance and evaluation, all war time developments in insecticides and equipment which gave promise of greater effectiveness or efficiency of operation have been tried out and adopted where possible.

When first reports were received during the summer of 1943 of the startling results of DDT, when used in mosquito control, we naturally were anxious to get a sample and try it out. This, however, was not easy to do since at that time the material was not being manufactured in this country and distribution of the small quantities imported was rigidly restricted. In the Fall of 1943, however, a small quantity was obtained and during November and December of that year a few experiments using the material as a larvicide were conducted. The results of these tests substantiated the claims made for it by earlier investigators, chiefly those at the Orlando Laboratory of the USDA to which considerable quantities of DDT had been allotted for experimental work in connection with the development of insecticides for the Army.

In February 1944, when increased quantities of DDT for experimental use became available a comprehensive program of investigation was undertaken to determine its suitability for use on the MCWA program and to develop formulae, equipment and procedures adaptable to large scale malaria mosquito control operations. This investigational work was undertaken at the Carter Memorial Laboratory, Savannah, Georgia under the direction of S. W. Simmons. A comprehensive report[1] on the developments at the laboratory recently has been published by Dr. Simmons and his co-workers and may be obtained from him on request.

During 1944, the Office of MCWA also participated in experimental work and practical demonstrations in the use of DDT in mosquito control carried on by the Tennessee Valley Authority, the Malaria Investigations Laboratory of the National Institute of Health and several State Health Departments. All of this work demonstrated the efficiency of DDT when properly applied in mosquito control. However, because of its toxicity to insects in general and possible danger of upsetting the balance in nature and thereby adversely affecting agriculture and wildlife, and controversy regarding its toxicity to man, the unrestricted use of DDT in mosquito control could not be advocated. The position of the Public Health Service in this connection is stated in a memorandum of agreement[2] covering use of DDT adopted by the Surgeons General of the Army and Public Health Service early in 1945.

Under the terms of this agreement large scale use of DDT on the MCWA program has been restricted to residual spraying of buildings for adult mosquito control and larvicidal work has been continued on only an experimental basis to develop suitable formulae and techniques of application of the material by hand and power sprayers and by airplane. An important feature of this experimental work is that of determining the hazards to fish and other wildlife which may result from the use of DDT in mosquito control and to devise ways and means of eliminating such hazards.

With the release of relatively large quantities of DDT to the public Health Service early in 1945 an extensive program for the residual spraying of houses was undertaken. This program has as its objective the control of indigenous malaria and the prevention of any increase in malaria transmission in this country which might result from the return of service men from malarious areas overseas. The work has been carried on principally in endemic areas where the cost of anopheline mosquito control by larvicides would be prohibitive

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1. Simmons, S. W., et. al.
The Use of DDT in Mosquito Control
Public Health Reports, Sup. #186, 1945

2. U. S. Army and U. S. Public Health Service
Use of DDT for Mosquito Control in the U. S. -- a joint statement of policy.
Public Health Reports 60(17); 469, 1945.

because of the small size of the population to be protected. Thus, it has supplemented and extended the regular malaria control program for war important areas. The basis for this residual spray program as most of you know is that of a residual deposit of DDT will kill mosquitoes which rest thereon and this lethal action persists for several weeks. By treating the interior surfaces of houses, where presumably anopheline mosquitoes most frequently attack man, such deposits will kill those mosquitoes which are most likely to have become infected with malaria parasites.

Under this program in 1945 the interiors of about 400,000 houses in 13 states of the south were given one or more applications of residual spray at the rate of 100 mg./sq.ft. This rate of application was decided on after reviewing experimental data which indicated that satisfactory rates of kill over a period of at least 3 months could be expected and in order to give protection to the greatest number of houses possible with the amount of material available. Only occupied houses together with outdoor privies were treated.

The spray formula used consisted of DDT, 3 lbs.; xylene, 3 qts.; Triton X-100, (emulsifier), 6 fluid oz. These quantities, when mixed, result in approximately 1 gallon of a 35% (w/v) DDT concentrate which for application is diluted with 13 gallons of water. This spray then has a DDT content of 2½% or 25 mg. per cc. Because of the reduced solubility of DDT in xylene at low temperatures a formula having a 20% DDT content is used when temperatures of 50°F or below prevail (DDT, 1 lb.; xylene, 2 qts.; Triton, 3.2 oz.). For use, this winter formula is diluted with only 7 parts water, thus giving a spray of the same DDT content as that of the 35% concentrate.

Mixing of the stock concentrate is possible by a variety of methods, ranging from the old-fashioned barrel rocker to orchard power sprayers. A useful power driven mixer for preparing the concentrate was designed for use on the MCWA program. It consisted of a 55 gal. steel drum and a small centrifugal pump assembly with appropriate fittings. This mixer is described in detail in a paper by H. Stierli[3] in the brochure previously cited.

Both hand-operated compressed air sprayers and power sprayers have been used to apply the emulsion. The former were found to be more useful because most of the spraying has been done in villages, suburbs of cities and in rural areas where houses are generally far apart. In densely populated areas when houses were sufficiently close, however, application by power sprayer may be more economical since two or more hose leads may be operated simultaneously in adjacent houses. The nozzle used produces a fan-shaped spray

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3. Stierli, H., S. W. Simmons and C. M. Tarzwell
Operational Procedures and Equipment Used in the Practical Application of DDT as a Residual Household Spray.
Public Health Reports, Sup., #186, 1945

pattern. With a hand sprayer operating at 49 psi the discharge rate is 0.2 gal./min.; with a power sprayer operating at a uniform pressure of 60 psi the discharge rate is .24 gal/min. Workers applying the spray soon learned to regulate the speed of arm movement to secure complete coverage at the proper rate. (190 sq.ft./min. with hand sprayer and 230 sq.ft./min. with power sprayer).

A pamphlet[4] on details of program operation has been prepared and since copies are available by writing the Office of Malaria Control in War Areas, Atlanta, Georgia, further discussion of operational[5] procedures will not be given here.

Indexes to the effectiveness of this widespread work were obtained in two ways:

1. Inspections of a small percentage of treated houses selected at random were made at intervals after spraying to determine results of the spray in keeping houses free of A. quadrimaculatus.

2. Precipitin tests were made of blood from quadrimaculatus stomachs collected around sprayed and unsprayed premises to determine the human blood meal rates. This method of checking resuls of spraying was planned since it was conjectured that if quadrimaculatus feeds principally on humans while indoors, as is commonly supposed, and these human feeders are being killed by resting on the sprayed surfaces, the general quadrimaculatus population about the sprayed premises should show a low human feeding rate when compared to that obtained in unsprayed areas.

Table 1 summarizes records of house inspections received to date. It shows that a total of 9,949 inspections have been reported and that these were made at intervals following spraying varying from less than 1 month to a maximum of over 4 months. Two hundred and seventy-six sprayed houses, or an overall percentage of only 2.8 per cent of those houses inspected contained quadrimaculatus during the afternoon. As has generally occured in demonstrations and other small scale DDT residual spray projects a gradual decrease in the effectiveness of the spray with age is evidenced. This is shown by the increase in the percentage of houses in which mosquitoes were found at successive monthly intervals after spraying. Inspections made less than one month after spraying indicated that 1.2 per

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4. Handbook of Residual Spraying - Malaria Control in War Areas, USPHS, Atlanta, Georgia, 1945.

5. Henderson, John M.
Operational Planning for the Malaria Control in War Areas DDT Residual House Spraying Program
Proc. 32nd Meeting N. J. Mosquito Exterm. Assoc., 75-80, 1945

cent of the treated houses were positive for quadrimaculatus. This percentage increased to 2.0, 4.8, 4.9, and 9.4 after intervals of 1, 2, 3, and 4 months respectively. The small number of inspections of houses made 3 or more months after spraying is due to the spraying schedule established, which called for re-spraying at 3 months intervals.

In table 2 the inspection records are grouped to show the effect of age of spray and numbers of quadrimaculatus in outbuildings on the per cent of quadrimaculatus positive houses. Only those houses with afternoon mosquitoes are considered as positive. These data show that for all spray ages the greater the density of quadrimaculatus around the premises, the greater is the percentage of sprayed houses which harbor mosquitoes. It is considered that these data merely indicate that greater numbers of mosquitoes enter houses in areas of high densities and for that reasen the chance that some will find non-lethal resting places in the sprayed houses is enhanced. The data in this table also indicate although with considerable irregularity, the decrease in spray effectiveness which occurs with age, the decrease being shown for each density group.

In order to fit the inspection routines into usual working hours, inspections were made throughout the day. However, houses in which quadrimaculatus were found during morning inspections were re-inspected during the afternoon. This procedure necessitated 356 afternoon re-inspections at which 74.4 per cent of the morning-positive houses were found to be free of mosquitoes.

Only a relatively small per cent of the total number of samples of quadrimaculatus bloods taken for determination of human feedings have as yet been tested. Howver, of 4,518 specimens collected on premises where the houses had been sprayed only 0.44 per cent were positive for human blood, while of 3,784 specimens from unsprayed premises approximately 3.0 per cent were positive for human blood. It is believed that these data which show 85 per cent fewer quadrimaculatus containing human blood about the sprayed premises are highly significant as indicating a lessened hazard of malaria transmission.

The foregoing discussion has been concerned with DDT residual applications at the rate of 100 mg. per sq. foot with re-spraying scheduled at intervals of 3 months. Because increased amounts of DDT are now available, during the coming season (1946) applications are to be made at the rate of 200 mg. per sq. foot since by using this heavier application the interval for respraying may be lengthened to four months or more. This procedure will result in a considerable saving since on the average the cost of labor for making the applications is three times as great as the cost of materials. Also, experimentally at least, DDT residual applications of 200 mg./sq.ft. have given significantly greater kills of mosquitoes than have applications of 100 mg./sq.ft. after even 5 and 6 months. Therefore, by using a 200 mg. application not only will it be possible to increase the interval between sprayings in endemic areas, but in the more northerly zones a single application in the Spring will suffice to give protection against the hazard of malaria infection for the entire mosquito season.

Just before coming to California, I had the opportunity of visiting the Carter Memorial Laboratory where I went over with the staff some of the past season's experimental work on larvicides. DDT in various concentrations in oil solutions, emulsifiers and dusts have been applied to breeding areas and their efficiency evaluated. Perhaps the most interesting part of this work from an operational point of view is illustrated by an experiment involving comparative tests of the effectiveness and cost of anopheline control by the use of Paris green, DDT dust and DDT in fuel oil. This experiment was conducted in the vicinity of Savannah, Georgia over an area of about 41 square miles which contained some 255 acres of anopheline breeding water surface including 75 miles of small ditches. The area was divided into three sections. In one section paris-green was applied as a 10% dust in lime. In another DDT was applied as a 1% dust in pyrophyllite and in the third section DDT was applied as a 1.25 per cent solution in fuel oil with 0.5% spreader (B 1956) added. All applications were made at weekly intervals and were at the per acre rate of 1 lb. of paris green, 0.24 lb. of DDT for the dust and approximately 0.1 lb. of DDT for the oil solution. Data covering the entire season on initial kills of larvae (the checks were made the day following application) show reductions of 80% for the paris green dust, 86% for the DDT dust and 98% for the DDT-oil solution. Another striking finding was that reinfestation of breeding areas after one week's time was at the rate of 64% in areas treated with paris green, 71% in areas treated with DDT dust, but only 12% in the area treated with the DDT-oil solution. This low reinfestation rate when using the DDT-oil larvicide has indicated that with this larvicide, the treatment cycle can safely be lengthened from the usual 7 day interval to one of 9 or 10 days.

In this test the dusts were distributed by ordinary hand operated rotary dusters. The DDT oil solution was applied as a mist over the water surface at a rate of only 1 gallon per acre. Knapsack sprayers of the usual 3 or 4 gallon type which were fitted with special atomizing nozzles were used to distribute the mist. No difficulty was experienced in obtaining good coverage with this small amount of material and the laborers became proficient in application after a few trials. The time spent per acre treated was only half that required for dusting or oiling under comparable conditions by usual methods.

Concurrent with these investigations detailed studies were made to determine the toxicity of DDT to other aquatic organisms. These have indicated that significant kills of fish resulted from the routine hand applications of 0.1 lb. DDT per acre. Other studies have indicated, however, that DDT applied by hand at the rate of only .05 lbs. per acre can be used without causing significant effect on fish life and that this smaller amount (.05 lbs. per acre) is sufficient when properly distributed to give effective control of mosquito larvae. On the basis of our present information therefore it is felt that routine use of .05 lb/a on an operational basis for larvicidal work is relatively safe. An added margin of safety in this respect is that most fish-important waters are relatively deep, and as a rule require only marginal treatment. Therefore, it is believed that the chance for DDT accumulating in hazardous concentrations is remote.

The distribution by airplane of concentrated larvicides and adulticides as mists and thermal aerosols has of course had extensive application during the war and remarkable results have been reported. As was previously stated, however, this type of mosquito control has been engaged in by the Office of MCWA only experimentally and this has been on a cooperative basis with other agencies, principally the Tennessee Valley Authority. The results of this cooperative work were highly satisfactory. They will not be discussed here since they have been published[6] in the Public Health Reports (Metcalf, et.al. 1945) which are available to those interested. It has long been known that where applicable in large scale work insecticides can be distributed most economically and efficiently by airplane, and there is no question but that mosquito control by airplane will become increasingly popular. However, there are many problems in connection with DDT distribution by this means which need solving. These are at present concerned no so much with the killing of mosquitoes, as with the effects that widespread distribution of this potent insecticide will have on wildlife generally. Many agencies including the Public Health Service are engaged in studies on this controversial subject and more comprehensive investigations are being planned.

Table 1

House Inspections on Residual Spray Program

Total houses inspected and per cent in which A. quadrimaculatus was found during afternoon inspections.

Months following spraying	Number of houses inspected	Houses with A. quadrimaculatus	
		Number	Per Cent
Less than 1	3225	38	1.2
1 - 2	3399	69	2.0
2 - 3	2337	112	4.8
3 - 4	774	38	4.9
4 - 5	214	18	8.4
Totals	9949	276	
Per Cent			2.8

6. Metcalf, R. L., et. al.
Observations on the Use of DDT for the Control of A. quadrimaculatus. Public Health Reports, Vol. 60, No. 27, July 6, 1945, pp. 753-774.

Table 2

House Inspections on Residual Spray Program

Effect of premise densities and age of spray on percentage of quadrimaculatus positive houses (afternoon inspections).

Months following spraying	Natural Resting Place quadrimaculatus densities						
	1-10	11-50	51-100	101-200	201-400	400+	All
	Per cent of Positive Inside House Inspections (afternoon)						
Less than 1	.7	1.5	2.5	1.5	1.0	6.5	1.2
1 - 2	1.0	2.9	5.1	3.7	3.2	6.8	2.0
2 - 3	1.8	4.3	6.9	11.5	12.7	37.7	4.8
3 - 4	1.1	7.3	5.4	18.9	16.0	55.5	4.9
4 - 5	1.5	10.4	0	11.7	85.7	66.7	8.4

Mr. Gray: Thank you very much Dr. Bradley.

Would any of you like to ask Col. Bradley any questions at this time?

Mr. Crandall: Does this spray kill honey bees?

Dr. Freeborn: There is a paper on the program that is going into that matter. I believe it will answer your question.

Mr. Gray: I'd like to ask a question myself about this matter of spraying only one gallon per acre by hand? How do you manage to spray as little as that?

Col. Bradley: The men have to be trained but they soon are able to get that amount on. An acre isn't very large. They move slowly, applying a fine spray. In effect it amounts to putting it on about as lightly as an airplane does. It means too that the men only have to carry a small load on their backs and that is good.

Mr. Coburn: How long would the contact have to be to actually kill?

Col. Bradley: A mosquito doesn't have to stay on the walls very many minutes to pick up a lethal dose. Sometimes it takes a little longer than others. I have a chart here which may be of interest. This chart doesn't exactly answer your question but it does in part.

Mr. Fitley: I would like to ask whether you got any ovipositing from quadrimaculatus after they had once contacted the sprayed walls.

Col. Bradley: I don't know that we even tried to note that. I think the specimens wouldn't live long enough to make any tests of whether they would oviposit. Most of the specimens used have been laboratory reared. Some may have been fertile.

Mr. Kitley: We did some experiments on macs and found we were getting it.

Col. Bradley: It is possible because you know Maculipennis and others as well will oviposit in a hurry when you stun them a little. They might be stimulated. However, on our programs we have been more interested in being sure they would die before they had a chance to develop parasites.

Mr. Kitley: In your work around war areas, how large an area did you find you had to cover in order to establish effective control?

Col. Bradley: We haven't used DDT in our larvicidal work around war areas. We have used DDT in residual treatment of houses beyond our control areas.

Mr. Kitley: How great a district around an airfield for instance, could you larvicide with DDT and have effective malaria control?

Col. Bradley: I don't believe it would need to extend beyond a mile of the post.

Dr. Freeborn: Mr. Paul Drescher will have a fog generator behind this building during the noon hour and I think again tonight. It is made by the Agricultural Chemicals Service Company. It is an excellent fog generator for dispersal of DDT. I hope you will all stop and see it in operation.

Mr. Gray: We are now to have a paper by Kenneth Maxwell on "Special Problems in Connection with the Navy's Use of DDT in the Field." Kenneth Maxwell is from the Chemurgic Corporation in Richmond, with which many of us are familiar.

Dr. Maxwell: Fifty thousand Japanese were killed in combat and twenty thousand additional by disease in the areas I operated in. The matter of mosquito-borne diseases was a critical factor in the early stages of the war. The most serious problem with which we had to contend was that of obtaining supplies. There was often a great scarcity of what we needed to do the job and we just had to do the best we could.

SOME ASPECTS OF THE NAVY'S USE OF DDT

By Kenneth E. Maxwell
Chemurgic Corporation, Richmond, Calif.

The military significance of insect borne diseases was evident early in the war. For example, on Guadalcanal where the outcome for a time seemed in the balance, it was estimated that 10,000 Japanese were killed in combat whereas about 20,000 additional were killed by diseases, among the most important of which was malaria and dysentery. The fact that mosquito and fly borne diseases were critical factors in some of the early campaigns explains the emphasis that was placed on insect control and the eagerness with which DDT was put into use.

One of the most serious problems was that of getting supplies of insecticides and equipment in the field where they were needed. There was often a scarcity of the right kind of insecticide and the right kind of equipment for applying it. This was due partly to shipping shortages and partly to the fact that as new materials like DDT came into the picture, new equipment and new methods were required. In the case of DDT, the part that it played during the early stages of the war was not as great as might be thought from the extensive use that was made of it later on, for the simple reason that it was not available. The first experimental sample of DDT that came to this country from Switzerland was reported to be first tried in October, 1942, two months after the Guadalcanal invasion. About one year later, that is by the end of 1943, the total United States production up to that time was said to be less than 200,000 pounds. Practically all of that was needed for louse powder and experimental use. As late as April of 1944, there was as yet no DDT available in the field for little more than experimental use insofar as mosquito and fly control was concerned. At that time, a number of the historic campaigns of the South and Southwest Pacific were already in the past and the war was well into the Central Pacific Towards the end of 1944, the Navy's allocation had been stepped up to about 400,000 pounds a month and fairly large shipments were being made to different parts of the world wherever they were needed most.

DDT was used by the Navy mainly in two forms, as the 100% technical grade and as an emulsion concentrate containing 25% DDT in xylene as a solvent plus an emulsifying agent. Most of the DDT was used as the straight technical grade dissolved in diesel oil. Actually, the emulsion concentrate was more useful since it did not require the time or labor to prepare it for use. However, only relatively small quantities were obtained in the field due to the fact that this material contained only 25% DDT and shipping space was critical. There was also a shortage of both xylene and emulsifier. Some dust containing ten per cent DDT was used but relatively little was sent out for mosquito control because of shipping problems. Later on, DDT was also added to the aerosol bomb.

The most impressive thing about the entire mosquito control program was that when DDT came into the picture, development of new methods and new equipment was necessary in order to efficiently take advantage of the extreme effectiveness of the material. In addition to residual spraying and the application of larvidides by hand, it also became feasible for the first time to apply larvicide sprays by means of aircraft.

Insofar as hand equipment is concerned, knapsack sprayers in general were unsatisfactory. Even though smaller nozzle openings were used, the sprayers frequently leaked, spilled oil on the backs of operators and gave mechanical difficulties that were hard to repair in the field. Two types of hand sprayers were adopted for distribution, the three-gallon, cylindrical, decontamination type sprayer and a small, three-quart sprayer. The decontamination sprayer, when specially equipped with oil-resistant hose and gaskets and the proper size nozzle opening, was particularly useful for applying residual sprays and was also extensively used for larviciding. The three-quart sprayer was of the flitgun type except that it was larger and sturdier and had a shutoff valve. It would hold sufficient spray to last the operator at least a half day and was extremely useful for spraying potholes and isolated mosquito breeding places. About 55,000 of these glorified flit guns were obtained by the Navy for mosquito control work.

Power driven equipment used for DDT spraying varied widely depending on what was available and what could be improvised on the spot. In general, the requirements called for sprayers of relatively small capacity and low delivery rate. Both positive displacement pumps and atomizing, compressor type pumps were used. At the end of the war, much remained to be done in the way of developing the most suitable type of power equipment for distributing DDT sprays.

Work was conducted on an experimental basis with smoke generators modified to produce DDT aerosols of sufficient volume to treat large open areas. The equipment that showed the most promise was the Navy's screening smoke generator adjusted to operate at a lower temperature than that required for screening smoke. A ten per cent solution of DDT in diesel oil, emulsified in water, was used. The steam pressure generated in the boiler tubes forced the DDT solution out in the form of very fine oil droplets, smaller than ordinary sprays but larger than smoke particles. The particle size was usually adjusted to an average of about 15 or 20 microns diameter. Some work was also done with a modification which mixed the insecticide with steam at the nozzle. Remarkably good results were obtained in some cases against both larvae and adults for distances of one or two thousand feet or more. In general, it was more effective against anopheline larvae than against culicines. The main disadvantage of the equipment is that conditions must be such that the generator can be transported on a vehicle along the windward side of the area to be treated. However, further improvements have been made in this type of equipment and it may find extensive use for mosquito and fly control over certain types of terrain.

Spraying by aircraft was done with a wide variety of planes and spraying devices. Carrier based planes were used during the early stages of the Iwo Jima and Okinawa operations, beginning on the eighth day on Iwo Jima and the third day on Okinawa. The carrier based torpedo bomber was probably the most useful during the assault stage since it had a high load capacity and was sufficiently fast and maneuverable for the purpose. For the most part, a five or ten per cent solution of DDT in fuel oil or diesel oil was used, applied at the rate of one or two quarts per acre. Spraying devices varied from those which gave typical spray droplets to those which gave very fine particles of "smoke" or aerosols. The latter was produced by introducing a DDT solution into the exhaust.

It was difficult to obtain accurate evaluations of the effectiveness of airplane spraying due to the fact that much of the work was done under combat conditions and, in many cases, mosquito populations before spraying were not known. In general, it was felt that the work was variable but worth-while. It was frequently the only method by which an area could be covered.

Space sprays for control of adult mosquitoes were important, particularly where larval control was impossible or difficult. Aerosol bombs enabled a great deal of adult control that could not have been done otherwise. The first aerosol bombs contained pyrethrum as the active ingredient. The concentration in the insecticide was high enough to kill adult mosquitoes but, due to the shortage of pyrethrum, was not used at a high enough strength to be very effective against flies. Later, when a method was found to add DDT to the aerosol bomb, it enabledit to be used against flies and other insects. Where DDT could be extensively used as a residual spray, the need for aerosol bombs and other space sprays was lessened.

An important use of DDT as a residual spray was the treatment of tents and mosquito nets. Because of the time and labor involved in treating shelter halves and mosquito nets in the field, plans were made to have DDT impregnated in the equipment at the factory.

In summary, it can be said that the Navy's insect control work was primarily operational, having drawn on a fund of information provided by the United States Department of Agriculture entomologists and other research workers who did much of the initial development work on the use of DDT. Successful mosquito control campaigns were conducted without DDT, particularly in the early phases of the war. However, DDT coming into the picture, together with changes in equipment and methods, greatly increased the efficiency of the mosquito control program.

<u>Mr. Gray</u>: We have time for quite a few questions. As you ask them, will you please give your name so we can get the stenographic record.

<u>Mr. Carpelan</u>: I would like to ask a question about the use of DDT. In Germany we had quite a bit of trouble getting it for typhus control. When we used the last carload they told us there was no more to be had for the European theater because it was being shipped to the Navy to use.

<u>Dr. Maxwell</u>: That was just propaganda.

<u>Mr. Embury</u>: Were you able to use modifications in 3 gallon sprayers so as to apply DDT effectively without excessive waste of material?

<u>Dr. Maxwell</u>: By the end of the war there remained a great deal to be done in regard to the problem of equipment. What was used was a combination or at least a compromise between what would be ideal and what was available. It was particularly true in view of the long delays that were required even after new types of materials and equipment were developed. It took some time to get them manufactured of course and then they still had to be shipped. Many things were extremely scarce. Many things lay on the docks two or three months

before shipping space was available. There was an excellent three or four gallon sprayer developed by the Army. It was very fine but it was never shipped out by the Navy because such long delays would be required.

Mr. Gray: We have with us a few people who have traveled considerable distances to get here. I want to welcome them especially. I hope we will hear from them during the discussions. I see that from Utah we have Dr. Don Rees and R. A. Wilkins. There is Richard Mondala from the State of Washington and E. J. Bumiller from Los Angeles. We had some correspondence with Commissioner Lee from Portland. Is she here?

Mr. Mondala; She is coming tomorrow.

Mr. Gray: There is Major Johnson from Hammer Field and quite a number of men from the Public Health Service.

Mr. Blumberg: I would like to ask Dr. Bradley whether the Public Health Service has been using a 2½% or a 5% emulsion of DDT and is it the concentration of the spray that is significant or the dosage.

Col. Bradley: The amount of DDT per foot has significance. It is the amount of material you get on the wall. We did use 2½% but now are going to use 5%. We will get more material on.

Dr. Freeborn: I suggest that Mr. Blumberg read some of the articles i on Soap and Sanitary Chemicals.

Mr. Henderson: Several of us were talking about the people who have left us since the last conference. We thought it would be proper if we had a moment of silence for those who have gone on.

Mr. Gray: That will most certainly be done but I think it might be well to wait till the close of the conference.

We have not made any arrangements for group meals while you are here because of various difficulties. The restaurant situation is still not too good. So each one will have to shift for himself. We will now adjourn for lunch and meet here again at 1:30.

The Conference re-convened at 1:30 p.m.

Mr. Gray: The Nominating Committee presentsthe following report.

For President	-	E. Chester Robinson
For Vice-President	-	H. C. Pangburn
For Secretary-Treasurer	-	Richard F. Peters

Are there any other nominations?

Mr. Blumberg: I move the report be accepted, the nominations be closed, and the nominees declared elected.

The motion was duly seconded and carried by unanimous vote.

Mr. Gray: Mr. Robinson will now preside at this afternoon's session.

Mr. Robinson: I want to thank the Association for making me President.

And now let's get right on with the program. We are to begin the afternoon session with a paper by J. E. Eckert on "The Effects of DDT on Beneficial Insects."

Dr. Eckert: I am interested primarily in honey bees and the relation of DDT and other chemicals to the overall picture of insect control.

I think the whispering campaign that went on about DDT could be compared to the destructive force of the atomic bomb. Every entomologist was asking about it and everybody else was telling someone else. It was thought to be so deadly to such a variety of animal life that many were saying it could not be used. But after considerable experimental work it was found that it could be handled with comparative safety if common sense principales were used to safeguard animals and plants.

THE EFFECTS OF DDT ON BENEFICIAL INSECTS

By J. E. Eckert, Apiculturist
University of California, Davis

The publicity that has been given to DDT since its rediscovery in the early stages of the recent world conflict was second only to that received by the destructive force of the atomic bomb. In many cases this chemical has lived up to the advance notice that it had greater killing power than any other insecticide. In fact, at one time it was thought to be so deadly to such a wide variety of animal life that many entomologists were implying it could not be used as a general insecticide because of its great destructiveness. As experimental results began to pile up, it was found that it could be handled and used with comparative safety if common sense precautions were taken to safeguard the animals or plants it came in contact with. The history of the war will show that DDT played an important part in the saving of many lives and in making life worth while.

DDT is very destructive to many species of insects including the beneficial forms. It is particularly destructive to the Hymenoptera and Diptera, in which orders occur many species of insects that render beneficial services to man through their activities as parasites of destructive insects or through their activities as pollinizing agents. DDT will also kill ladybird beetles, lacewings and other predators that tend to keep the destructive forms of insects in check. These beneficial insects frequently render services of far greater value than the value of the crops the injurious forms destroy. Many of our fruit, vegetable, seed and pasture crops, as well as much of our native vegetation, is either dependant upon or made more productive by the pollinating insects. It would be poor economy, therefore, to use any chemical that would have a greater overall destructive effect than the returns secured through the destruction of injurious or pestiferous insects.

DDT has a greater killing power than a majority of the present known chemicals because it acts both as a stomach poison and contact insecticide. It is now generally well-known that many insects are killed when their feet come in contact with this chemical for a period of time that varies with different insects. DDT is also insoluble in water but will kill many insects when minute particles of the chemical are ingested. Repeated experiments have indicated that DDT gradually loses its toxicity on exposure to air and sunshine, a desirable characteristic that is lacking in the arsenicals.

Because of its combined killing power, DDT can be used in far lower concentrations than a majority of other chemicals that are used as insecticides or larvacides. My observations have shown that it takes a higher per cent of DDT than arsenic to kill honeybees when the the two chemicals are fed to them in sugar sirup. This fact, coupled with the possibility of DDT being used in such minimum quantities for the control of mosquitoes, together with the destructible character of the chemical, tends to make DDT a safer poison than the arsenicals when the safety of the pollinating insects is concerned.

All of our pollinators and many of the adult forms with parasitic habits depend on pollen or nectar for all or a portion of their food supply. Pollinating insects, in particular, usually visit only the blossoms and seldom crawl over the leaves and stems of plants in seeking nectar and pollen. Consequently, if DDT is applied only when plants are not in bloom and is confined to the areas treated the danger to pollinators and other beneficial insects will be minimized.

Another factor that will aid in preserving beneficial insects for the services they normally render is the form and manner in which DDT is applied. Dusts are prone to drift with the wind and are usually deposited in considerable quantities miles from the areas treated, especially when they are applied by airplane or by high air-velocity-machines. The finer the particle size and the stronger the wind, the greater will be the extent of the drift. These drifting poisons may kill many beneficial insects if they fall on plants in bloom. The mere fact that they do drift either reduces their effectiveness or requires that greater percentages of the toxic materials be used to effect control. The application of DDT in liquid media more nearly confines the chemicals to the areas treated and permits the use of only minimum amounts of DDT to secure the desired results. When they fall on the surface of water or on vegetation, the droplets tend to spread and thus disperses the toxic material over a still greater surface. If these oils are applied by the drip method or by direct application to the water surfaces, the danger to beneficial insects will still be lower than if they are applied by airplane. In the interest of economy of application and to overcome certain physical limitations of ground equipment it is desirable in many instances to resort to the airplane for depositing the larvacides over areas in which mosquitoes breed. Fortunately, methods have been developed for the application by airplane of minimum quantities of DDT in oil and undoubtedly continued study of the physical factors involved will produce greater refinement and still more efficient results.

Wave and wind action tend to concentrate the dusts as well as the oils along shore lines in concentrations of DDT that might be destructive to bees as well as to other animal life. The presence of oil on the surface of the water will tend to make such places less attractive to bees and thus serve to prevent their loss which would not be true if dusts were used.

Many of the wild or solitary bees use ditch banks or uncultivated areas as nesting sites, so the more nearly the DDT media are confined to the areas in which mosquitoes actually breed, the less will be the danger of the application of DDT to such beneficial insects.

Thus far our observations have indicated that no appreciable injury has resulted to colonies of honeybees located in the limited number of areas treated with DDT for mosquito control in California. Nor have we received any reports of damage to bees from other sections in the United States. We have therefore formed the opinion that if DDT is continued to be applied in minimum concentrations for the control of mosquitoes and of flies, and is confined largely to the areas in which these pests breed and if the materials are not applied when major nectar or pollen plants are in bloom in these areas, no significant injury to our bee population is likely to occur. These observations are strengthened by others dealing with the application of DDT in far larger concentrations to cultivated crops, following which no appreciable loss of colonies have occurred. Time and careful checking of the results will reveal what is actually happening to our beneficial insects when far larger areas are treated with DDT for mosquito control. We should always keep in mind that we are dealing with a very potent chemical that will kill beneficial insects and animals as well as the destructive forms we are attempting to control and not become careless with this or other chemicals used by similar methods in the interest of public health and comfort.

Prof. Herms: Will there be opportunity for further comments? I suppose no other federal agency is so much concerned with the use of DDT as is the Bureau of Entomology and Plant Quarantine. I want to call attention to a press release on January 13th coming from Washington that had some information in it which pertains to this problem. It will help emphasize some of the things mentioned.

One of the early fears was that DDT would destroy too many bees. Tests have indicated it is not as fatal to bees as was at first feared. It is considered to be less deadly than arsenical chemicals and we may come around to the belief that it is better than other poisons. In regard to large scale use for some forest insects, it is found that the beneficial insects have failed in holding the parasitic population down and that something is needed to bring things into balance. DDT may be of benefit in that connection in restoring the balance of nature.

Mr. Robinson: At this time I would like to call attention to some of the new superintendents who are here today and haven't previously been in attendance. I will ask them to rise as I call their names so we may all know them. It is a great pleasure to have them with us.

There is Mr. Blazek from Three Cities; Crandall from Durham; Henderson from Tulare; Omlor from Delano; and Orion Murphy from Redding and Clear Creek -- the latter not new but with us for the first time. From the new district at Ballona Creek near Los Angeles there is Mr. Bumiller and Mr. Crawford who works with him. From Turlock we have Ed Washburn and one of his trustees, Mr. Domecq. Raley is here from Sutter-Yuba; Geib who has taken Fred Hays' place in the Dr. Morris District; Dick Peters back with the State Health Department and our new Secretary-Treasurer; and also our new Vice-President Mr. Pangburn.

And now E. E. Horn is to read a paper written by Dr. Clarence Cottam on "The Effects of DDT on Various Fish and Wild Life."

STUDIES OF THE EFFECTS OF DDT UPON FISH AND WILDLIFE

By Clarence Cottam
Chief, Division of Wildlife Research
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U. S. Department of the Interior

INTRODUCTION

Even during the war the potency of DDT as an insecticide attracted the attention of many diverse groups. Wildlife conservationists, ornithologists, ichthyologists, horticulturists, and apiculturists, as well as entomologists, mosquito- and pest-control workers, and agricultural groups, wondered just how their interests might be affected. The lifting of military restrictions placed in their hands a highly efficient substance, its beneficial or harmful significance to be determined by their use of it.

Any effective insecticide is a two-edged instrument. Every experienced control worker realizes that the more potent the poison, the greater the danger of damage if the poison is incorrectly used. Fortunately, DDT, like most organic and mineral poisons, is specific to a degree: it does not strike with equal effectiveness the innumerable animal and plant species; if it did, the advantage of control of undesirable forms would be more than offset by the detriment to desirable forms. The problem is to determine the degree, time and method of use that will control mosquitoes without halting pollination, destroy crayfish, without killing clams, or check forest insects without starving the young of insectivorous birds.

Initial studies were made in 1943 and 1944 by workers in the Bureau of Entomology and Plant Quarantine (U. S. Department of Agriculture), the U. S. Public Health Service, the U. S. Food and Drug Administration, the Department of Agriculture of Canada and the Royal Ontario Museum of Zoology, the Illinois Natural History Survey and the University of Missouri.

Recognition of the need for more detailed information resulted in 1945 in concurrent studies by interested agencies and organizations. On areas treated with DDT, members of the Bureau of Entomology and Plant Quarantine watched the effects of the poison upon insects, while personnel of the Fish and Wildlife Service (U. S. Department of the Interior), assisted by the Forest Service (U. S. Department of Agriculture), the National Audubon Society and other organizations, observed the effects upon birds, mammals, fishes, and other forms of wildlife. The principal field investigations were made in Maryland and Pennsylvania, where the studies included insects, mammals, birds, amphibians, and fishes. At the Fish and Wildlife Service's Patuxent Research Refuge, Bowie, Maryland, laboratory studies were made to determine the toxicity of DDT to mammals, birds, and amphibians, and at their Fishery Station at Leetown, West Virginia, to determine its toxicity to fishes.

Though most insect pests can be controlled with DDT oil sprays of concentrations ranging from 0.1 to 1.0 pound an acre, most of the areas studied in 1945 were sprayed by airplane with 0.2 to 5 pounds of DDT (in oil solution) an acre. Repeated applications might have caused more positive results, but most of the areas studied received only one application. Variant factors, of course, included weather conditions, topography, and paucity of landmarks (which apparently caused small portions of some areas to be missed or covered twice).

The laboratory studies during 1945 revealed a wide variation in the effects of DDT upon different groups of vertebrate life and some variation within a given species. These studies indicated that effects within a given species might depend upon the type of solvent or the kind of food ingested with the poison, as well as upon other factors.

The long-time effects of DDT on wildlife must be evaluated. During 1946 the U. S. Public Health Service and the Fish and Wildlife Service will study the effects of repeated small applications of DDT for control of larvae of malarial mosquitoes. Experiments will be undertaken to determine the effects of repeated applications of low to high dosages for control of orchard or field crop pests, and to determine more precisely the maxima that different forms of wildlife can tolerate.

To date, studies have centered upon the effects of DDT on wildlife of forest areas and on fish. Studies are now under way to determine the effects of DDT upon marsh and aquatic organisms, especially in the relation of malarial control to wildlife. A pressing requirement for the future is a study of the effects of DDT as applied to agricultural crops and the effects of such control practices and procedures upon the wildlife and game dependent on an agricultural environment, upon which about 80 per cent of our game--and a very high per cent of our nongame and insectivorous birds and mammals--are largely dependent.

FIELD STUDIES

Patuxent Research Refuge, Prince Georges County, Maryland

On June 5, 1945, a 117-acre tract of well-drained forest on the Patuxent River bottomland was sprayed by airplane with an oil solution of DDT applied at the rate of 2 pounds an acre. The solution was made of 1 pound of DDT to 2 pints of xylene and 5.7 pints of No. 2 fuel oil; 2 gallons of the solution were applied to each acre of land.

Many insects, particularly adult pest mosquitoes, were killed within a few days after the application, but most species appeared to occur in normal numbers 2 or 3 weeks later.

The short-tailed shrew and the deer mouse, insect-eating mammals, were censused before and after the application, but no reduction of statistical significance was noted.

A bird census was made before the spraying on an area within the 117-acre tract, on an area 1-1/8 miles distant, and on a third area immediately adjacent to the tract. In the first week after the spraying the bird population dropped about 12 per cent in the sprayed area, and 5 and 10 per cent, respectively, in the second and third areas. These figures indicated decline in population because of predation or completion of nesting rather than because of DDT.

No difference in hatching or survival was observed for 23 nests (containing eggs or young) in the sprayed area as compared with 12 in the control.

At 5 pounds an acre, DDT was applied with a hand atomizer to a series of nests (each in 1 square foot of sprayed area). Observers noted no detrimental effect upon hatching or survival, no abandonment of nests.

In a series of 20- by 50-foot artificial ponds containing assorted amphibians, two ponds were treated with oil; two, with a 1-pound an acre oil solution of DDT; two, with a 5-pound an acre oil solution of DDT; and several were untreated. One of each pair of ponds was shallow; the other, deeper. In the deeper of the two ponds treated with 1 pound of DDT an acre, no sick or dead were found; in the shallow pond (5 inches at the center) several frogs and large frog-tadpoles and a young water snake were killed. In both ponds treated with 5 pounds an acre, several frogs and large frog-tadpoles were killed. Some remained alive in all the treated ponds.

The 117-acre tract included 9/10 of a mile of the Patuxent River, normally a muddy stream with a flow of about 130 cubic feet a second. Nine and a half hours after the spraying 95 dead fish were removed from a stop net at the lower end of the sprayed section. Surface feeders--fallfish, common shiner, bluegill sunfish, eastern madtom, and silverling minnow-- were most seriously affected; bottom feeders-Johnny darters and rosy-sided dace--were abundant in seine hauls, but no dead were found.

Apparently DDT driftage killed all the golden shiners and pumpkinseed sunfish in a small gravel-pit pond about 150 feet from the sprayed area. Red-bellied sunfish, yellow perch, and about a third of the bluegills in a live-box in the same pond, survived.

Each of eight shallow, 20- by 50-foot, soft-water ponds was stocked with 30 large fingerling bluegill sunfish, 15 red-bellied sunfish, 14 yellow perch, and 3 adult white crappies. Three ponds were sprayed with 0.1 pound, two with 0.5 pound, and two with 1.0 pound of DDT in oil to the acre; the eighth was unsprayed. At 1 pound an acre, one pond had an 80-per cent loss in bluegill sunfish, 93-per cent loss in red-bellied sunfish, and 78-per cent loss in yellow perch. In ponds sprayed with 0.5 pound an acre there was serious mortality. In a pond sprayed with 0.1 pound an acre, there was a 43-per cent loss among all species.

Lackawanna County, Pennsylvania

Between May 24 and June 1, 1945, near Scranton, Pennsylvania, an oil spray of DDT at 5 pounds an acre was applied by airplane on a 600-acre tract of forest land including a 40-acre bird-censused area. On June 9, an oil spray at 1 pound an acre was applied by airplane to a 350-acre tract including another 40-acre bird-censused area.

Within a few hours the 5-pound spray eliminated the gypsy moth and other tree-feeding caterpillars and reduced many other insect populations, although several of these groups regained their normal numbers in 3 months. Some species seemed unaffected; a hive of bees came through in good condition. The 1-pound application caused a nearly complete kill of gypsy-moth larvae and a conspicuous but temporary reduction in the general insect population.

Within 48 hours after the 5-pound application five birds with symptoms of DDT poisoning were found; all died. In two weeks the population was reduced from 1.6 pairs to 0.5 birds an acre. Species killed included red-eyed vireo, black and white warbler, ovenbird, redstart, and scarlet tanager. On the area sprayed with the 1-pound solution the bird population declined from 2.7 to 2.6 pairs an acre. On a third censused area (unsprayed) the population dropped from 2.7 to 2.4 pairs an acre, owing, presumably, to completion of nesting or loss by predation.

On August 9, 1945, a 3-mile section of Ash Creek, near Clifton, Pennsylvania, was sprayed by airplane with an oil solution of DDT, applied at the rate of 1 pound an acre, of which only 0.25 pound an acre of DDT actually reached the stream. Measurement of the drift of insects 2 hours later indicated the passage of about 60,000 an hour at the surface and 15,000 an hour at the bottom. Nine and a half hours after spraying, the rate at the surface had dropped to 30,000, that at the bottom to 11,000. Meantime, the drift of insects on a control stream was 704 an hour at the surface and 469 at the bottom. Poisoned fish began drifting into the weirs 12 hours after spraying; 69 per cent of all observed losses occured within the first 34 hours. The warmer-water fishes--common shiners, common suckers, and golden shiners were affected first, most of their mortality occuring within the first 2 days. It was estimated that less than half were killed. Brook and brown trout were more slowly affected, their losses lasting a week. Apparently about 1.3 per cent of the brook-trout population (27 from an estimated 2100) were killed.

Black Sturgeon Lake Area, Ontario

The Department of Agriculture of Canada reported that 50 to 60 per cent of the spruce budworm larvae were killed by the application in May and June 1945 of 1 pound of DDT an acre on 100 square miles of spruce-fir forest.

Bird populations ranged from 2.0 to 3.6 pairs an acre in three sprayed 25-acre areas, as compared with 4.4 pairs in a control area. Four birds with DDT jitters were found, but apparently no measurable changes were effected in the adult populations or in the nests.

Savanna Ordinance Depot, Carroll County, Illinois

The sixth Service Comman sprayed 4,000 acres at 30-day intervals between August 5 and October 6, 1945, with applications (5 per cent solution in No. 2 fuel oil) ranging from 0.2 to 0.5 pound an acre on different areas.

Mosquitoes were readily killed by this solution of DDT when applied at 0.2 to 0.5 pound an acre.

Most of the crayfish were killed by 0.5 pound of DDT to the acre.

Racconns that fed upon the crayfish showed no ill effects. Other vertebrates apparently were unharmed.

Bird nesting populations were little affected, as few nests in this region were occupied after August 1. No direct effects on birds were noted, but the swallows withdrow to adjacent areas. Toothed herring and several species of shiners and dace were killed by the application of 0.5 pound of DDT to the acre in agitated waters.

Island Beach, Ocean County, New Jersey

Partial control of mosquitoes was achieved by the airplane spraying (July 11, 1945) of an estimated 0.5 pound of DDT an acre along the southern 6 miles of Island Beach, including the shallow shore waters of Barnegat Bay.

Swallows and insectivorous birds, which had been numerous in the area, left at once. No sick or dead birds were found.

Blue crabs, plentiful before the spraying, moved temporarily from the sprayed waters but were abundant in unsprayed areas. Returning after a few tides had cleared these waters, the crabs were caught a week later by the residual poison carried from the island to the bay through mosquito ditches after a hard rain. On a 200-yard stretch, 150 dead or dying crabs were counted. An estimated 100,000 small dead fish (menhaden, mullet, and killifish were found along 5 miles of the Barnegat Bay shoreline.

Other Field Observations

In Clatsop County, Oregon, partial control of the hemlock leaf looper was effected on 3,000 acres with various solutions, most of which contained less than 1 pound of DDT an acre. A large percentage of the crayfish in the Necanicum River (which crossed the tract) were killed.

At Fort Knox, Kentucky, most of the mosquitoes and many other insects were killed by the application of 0.4 pound of DDT to the acre. In one bottomland pond that probably received a larger dosage, a large proportion of fish--including more than 100 shiners and sunfish--were killed.

Mosquitoes and greenhead flies were temporarily eliminated on part of Wallops Island, Virginia, through the application of an unreported amount of DDT late in August. During the first 2 days after spraying mortality was very high among blue and fiddler crabs and fishes.

A dusting of DDT (25 pounds an acre) at Blowing Rock, North Carolina, in May and June 1945, reduced Japanese beetles to a third of the 1944 population. Within 3 days, however, 30 sick or dead birds and 11 abandoned nests were reported on the 217-acre tract dusted, and 12 sick or dead birds and 3 abandoned nests were observed on adjacent areas.

At localities in Maryland, Nebraska, Colorado, Wisconsin, and Ontario, wildlife was affected only slightly by applications of DDT in oil solution at rates ranging from 0.2 to 5 pounds an acre. In Utah, where a field of alfalfa was dusted with 1.5 pounds of DDT an acre, lygus-bugs were controlled and birds were apparently unaffected.

LABORATORY STUDIES

Wild-trapped field mice showed little toxic reaction to diets containing 0.01. 0.02, 0.04, and 0.10 per cent of powdered DDT; two of five fed 0.2 per cent died; all of five fed 0.40 per cent died. In a 30-day trial field mice showed no ill effects from a 5-pound oil solution of DDT sprayed on their cages nor from DDT-sprayed oats.

Cottontails fed crystalline DDT were temporarily affected by 0.2 per cent; two of five died after a diet containing 0.4 per cent. Crystalline DDT administered with a stomach tube caused no symptoms of poisoning at doses ranging from 500 to 1500 milligrams per kilogram of body weight; at 1500 mg/kg one of three cottontails showed tremors but recovered; two of four receiving 2000 mg/kg died on the 3rd and 13th days; two of three receiving the 2500 mg/kg dosage died on the 7th and 12th days.

Young bobwhites were tested with a mash diet containing DDT at percentages ranging from 0.4 to 0.005 during a 63-day period. Some losses occurred at the lowest level; 50-per cent loss occured at the 0.025 level; all those fed more than 0.05 per cent died.

Adult bobwhites were tested with single oral doses of DDT in crystalline form, gelatin capsules, or vegetable oil solution. Dosages of 200 mg/kg in crystalline form were required to cause a significant percentage of deaths; mortality increased with larger doses, but there were survivals even at 1000 mg/kg. DDT was much more toxic in vegetable oil solution; at 50 mg/kg one of six died; at 60 mg/kg four of six died; and at 75 mg/kg five of six died.

Wood-frog tadpoles were killed within 3 to 5 days by application of DDT at 5 pounds an acre. Treatment with oil alone had no ill effect.

Brook and rainbow trout (5 to 7 inches long) were unaffected by an oil solution of DDT at 1 pound an acre, sprayed on 125- by 8- by 2-foot raceways receiving 109 gallons of hard spring water a minute; whereas 4 to 12 per cent of the bluegills (3½ inches long) were killed within 5 days by the same treatment.

Small ponds containing bluegills (3½ inches) and largemouth bass (5 inches) were treated with DDT at 1 pound an acre in an oil solution, an emulsion, and a suspension: in a week the suspension killed very few fish, the solution killed 50 to 60 per cent of the bluegills but very few bass, and the emulsion killed all of both species.

In another experiment no bluegill sunfish died after feeding for three days on flies sprayed with a 12-per cent oil solution of DDT at 1 pound an acre.

SUMMARY

1. Principal investigations were made on forest tree insects in Maryland and Pennsylvania.

2. Applied chiefly by airplane as an oil spray, concentrations of DDT ranged from 0.2 to 5 pounds an acre. The maximum used anywhere was 25 pounds an acre in a dust.

3. The amount of DDT actually on an area showed considerable local variation from the specified rate of application, owing to weather, lack of landmarks, defective apparatus, and different density of vegetation.

4. Higher concentrations of DDT caused pronounced mortality in wildlife; lower concentrations caused slight or unapparent mortality. Invertebrates and cold-blooded vertebrates were more readily affected than were birds and mammals.

5. In a single trial, DDT was much more toxic in emulsion than in oil or suspension.

RECOMMENDATIONS CONCERNING EFFECTS ON WILDLIFE

1. Use Only If Necessary. Weigh the need for insect control against the harm to beneficial forms. If a large area is involved, consult county agricultural agents, State or Federal entomologists, wildlife and fishery biologists, and U. S. Public Health Service officials.

2. Use Minimum Necessary Dosage. To avoid damage to fishes, crabs, or crayfish, use less than 0.5 pound an acre in oil solution; to avoid damage to birds, amphibians, and mammals in forest areas, use less than 2 pounds an acre. Emulsions are more damaging than DDT in other forms.

3. Apply Carefully. Use only in calm, dry weather and only where needed. For application by airplane provide careful plane-to-ground control to insure even coverage.

4. Leave A Sanctuary. To disturb wildlife as little as possible in forest pest control, alternate whenever possible treated and untreated strips.

5. Time The Application. Adjust crop and mosquito-control applications as much as possible to avoid the nesting period.

6. Avoid Spraying Water. Do not apply directly to open water areas in concentrations greater than 0.01 or 0.2 pound an acre. Do not spray near open water areas on windy or breezy days, as this tends to concentrate DDT in bays and on shorelines.

7. Watch The Effects. Before and after use of DDT make careful observation on all forms of wildlife.

Mr. Robinson: Thank you, Mr. Horne.

And now Professor Hoskins has a paper on "Newer Knowledge of the Toxic Action of DDT."

NEWER KNOWLEDGE OF THE TOXIC ACTION OF DDT

By W. M. Hoskins
University of California, Berkeley

The remarkable behavior of DDT as an insecticide for many different kinds of insects has stimulated much interest in the reasons for its strong toxic action. The physical and chemical properties of DDT give but scant clues, for the material is a colorless, crystalline solid, melting at 108.5°C, practically insoluble in water and stable under any ordinary conditions. In fact, its chemical inertness caused the original discoverer, Zeidler (Berichte der deutschen chemischen Gesellschaft 7, 1180-1, 1874), to write only a brief report on its synthesis and then to consign it to the oblivion that lasted for almost seventy years. However, two points of interest may be noted: it is readily soluble in fatty materials from both animals and plants and under certain conditions hydrochloric acid may be separated from the DDT molecule.

The general inertness of DDT undoubtedly is responsible for its persistent effect after application, e.g., against flies and mosquitoes alighting on a sprayed wall or, to a lesser degree, against codling moth larvae seeking to enter a sprayed apple. The effectiveness does diminish with time and there is some uncertainty regarding the reason. The most obvious explanation, doubtless, is that weathering removes the deposit. This is supported by the results of analyses which show a decrease in residue as time elapses.

A rather remarkable property of DDT is its tendency to flake off walls and other treated surfaces in small crystals. This first came to the attention of experimenters who found a high mortality of mosquitoes occurring in clean cages which were kept in a room treated previously with a spray containing DDT (Metcalf etal, Public Health Reports 60, 753-74, 1945). Itwas natural to attribute this toxic action to volatile DDT, i.e., it might act as a fumigant. This explanation was ruled out by the fact that mosquitoes confined over DDT but out of contact with it are not affected, at least for a matter of several days. The mortality due to flaking is controlled by the opportunity for the detached particles to reach the insects. For instance, the following knockdowns were obtained with adult A. quadrimaculatus confined in small cloth-topped cartons set in various positions in a room whose walls and ceiling had been sprayed with DDT in kerosene; in 24 hours; center 10%; corner near walls 30%; center but with a piece of cardboard held 2 inches above the cloth top 0%. After 48 hours the knockdowns were 100%, 100% and 20%, respectively. Controls were entirely unaffected.

Loss of DDT by vaporization from a treated surface cannot be dismissed entirely, however. Experiments in my laboratory indicate that about a quarter of the DDT put on filter paper by dipping in a benzene solution escapes in one month when the paper is kept at ordinary temperature and in rather subdued light. Under the conditions, but little of this loss could have been by flaking. It may be concluded that loss of DDT occurs both by flaking and by volatilization, but the latter is too slow to cause a fumigation effect.

The possibility that DDT is broken down, e.g., by sunlight, simpler products which do not give the test for DDT and are not effective, or to a lesser extent, against insects has been suggested. Such degradation products could even be toxic to man and animals. The evidence on this point is extremely scanty but it indicates that no such reactions occur and, tentatively, it seems reasonable to conclude that decrease in effectiveness of a treated surface is primarily due to disappearance from it of DDT. Of course, absorption into porous wood, covering over with dirt and similar processes will also have effects in the same direction.

One of the most striking characteristics of DDT is the minute amount needed to cause poisoning and death in certain insects, especially various Diptera. An example is given by a simple experiment which I once made with adult fleshflies. A minute drop of a dilute emulsion was placed upon a cork and immediately taken up with an absorbent paper towel. The surface of the cork was rubbed excessively with the towel until some of the upper layer must have been removed. Then flies were allowed to barely touch the treated region with the two front feet. Within 15 minutes they showed typical DDT jitters. It has been calculated by Lauger etal (Helvetica chimica Act 27, 892-928, 1944) that one millionth of a microgram of DDT per square centimeter is sufficient to poison flies walking on the surface. On the other hand, some insects are extremely resistent to this material. We have smeared a strong solution of it in oil upon the abdomen of American roaches without producing any visible effect and some of the grain beetles, Aphanotus sp. showed no sign of distress until kept for several hours in a 40% dust.

The reasons for such striking differences in sensitivity have aroused much interest. Dr. Wiesmann of the J. R. Geigy Company has advanced the hypothesis that DDT penetrates the integument of insects only in the region of sensory organs and through the intersegmental membranes. He explains that over the sensory organs the cuticle is represented by only the epicuticula. This is a thin lipoid-containing membrane through which DDT can pass. The ready entry through the feet of flies is then to be expected since they bear numerous organs of taste. Likewise the intersegmental membranes are the thinnest portions of the body covering. The experiment with the American roach mentioned just now shows, however, that all intersegmental membranes do not readily admit DDT. Wiesmann's basic hypothesis is that the DDT molecule contains a lipoid-soluble portion which enables the whole molecule to dissolve in lipoids, plus a toxic portion to which the physiological effects may bd attributed. The typical symptoms of nervous disturbances shown in both insects and mammals by incoordination of movement and the DDT jitters are consistent with this hypothesis since all principal nerves and ganglia are closely associated with lipoid membranes. It may be pointed out, however, that DDT differs from other nerve poisons in that the effects develop slowly and mortality is greatly delayed in comparison with such substances as pyrethrum or nicotine. Also, numerous capable investigators have failed to observe any changes in the gross or microsopic appearance of nervous tissue in insects dying after exposure to DDT. Such considerations perhaps justify the feeling that death from DDT may involve much more than a toxic effect limited to the nervous system.

A theory of much interest, but as yet of uncertain validity, is that DDT is toxic because following its passage through the integument and distribution to various tissues of the body, it splits out hydrochloric acid in some highly vital tissue or tissues (Martin and Wain, Nature 154, 512-3, 1944). Now DDT does undergo this reaction in vitro but only at an elevated temperature and in the presence of strong alkali or certain heavy metals such as iron. The possibility of such a reaction occuring within living tissues would seem to depend upon some as yet unknown enzyme capable of producing this effect and located within a vital tissue, for such liberation of acid in most regions of the body could not possibly have a serious effect because of the minute quantity concerned.

An attempt to confirm or disprove the theory just described was made by the English worker Busvine (Nature 156, 169-70, 1945 who studied the ease with which a number of the DDT family of compounds split out hydrochloric acid. True to prediction, DDT ranked first but the dimethoxy compound, which has a CH_3O group in place of each of the Chlorines in the two benzene groups, loses hydrochloric acid slowly though it is very nearly as toxic as DDT itself. Even if this theory is valid, the problem still remains of finding the vital tissue in which the liberation of an infinitesimal amount of acid would have fatal results.

Another interesting suggestion was made by three Brazilian workers (Vaz, Pereira and Malheiro, Science 101, 434-6, 1945) who recalled that the effects of such nerve poisons as carbon tetrachloride are relieved by injection of soluble calcium compounds. They found that effects of DDT upon dogs are similarly decreased or prevented by injection of calcium chloride. It is uncertain that a similar situation exists with insects. The Swiss experimenters have claimed that injection of calcium ions into the body of flies retarded the onset of symptoms of DDT poisoning but we were unable to find any effect with roaches.

This sketchy account of some of the work undertaken with the hope of learning how DDT acts has, I fear, thrown little light upon a very dark subject. Here, as seems to be the usual case with insecticides, practice has gotten far ahead of theory and we know much more about "how" than about "why."

Mr. Robinson: Thank you, Dr. Hoskins.

We will follow immediately with a further discussion of this important matter by Professor Anderson.

PUBLIC HEALTH HAZARDS OF D.D.T.*

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The late Dr. Herbert O. Calvery, Director of the Food and Drug Administration Laboratory, Washington, D. C. has recently published a report entitled, "D.D.T. is Poisonous". He stated that the safe level of D.D.T. in human foods should not exceed 10 parts per million, based on observations in animals. "At a 100 mg./kg. ratio, 7,000 mg./man might be lethal to 50 per cent of the people. I, myself, would not risk more than 70 milligrams or one milligram per kilogram (a kilogram is 2.2 avoirdupois pounds).[1]

While D.D.T. is a toxic substance, its toxicity to man is of relatively low order and permits its use, provided reasonable precautions are taken. When applied in powder form it is not likely to be of toxicologic importance, unless food becomes contaminated and the poison is swallowed accidentally. In oil or oil miscible solvent D.D.T. may be absorbed across the skin and mucous membranes, and cumulative action may follow. The poisonous properties of D.D.T. are irregular and in general resemble those of phenol (carbolic acid). In animals and man loss of appetite, loss of weight, generalized tremors (quivering or shaking sensations) excitability and finally convulsions may follow exposure to excessive amounts. Destruction of liver tissue, and of kidney and muscle tissues as well, is most characteristic, yet grossly the affected individual exhibits toxicity related to the nervous system. However, despite widespread application, reports in the literature do not include fatal cases, although there is evidence that fatalities, complicated by the solvent used, have occurred. Since no specific antidote is known, every precaution should be taken to protect animals and man.

Draize, et al.[2] have reported that following skin application animals exposed to 5 per cent D.D.T. in powder form showed no local or generalized (systemic) toxic effect. Solutions of D.D.T., however, definitely sensitized guinea pigs. After 30 days, rabbits, rats and guinea pigs died when 150 mg./kg./day of D.D.T. was applied in 30 per cent solution as an inunction (smeared on and rubbed into skin). Animals and probably man show wide variations in susceptibility. Since individual susceptibility to a poison cannot be anticipated or predicted, it would seem that the unlimited use of D.D.T. solutions on the skin is not free from danger.

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* Read before the Mosquito Abatement Conference, University of California, Berkeley, February 25, 1946.

1. Food Packer, April, 1945

2. J. Pharmacol. and Exper. Therap., <u>82</u>: 159 (Oct.), 1944.

If D.D.T. must be applied in solution, then choice of solvent is most important. Some of the solvents proposed, such as carbon tetrachloride are themselves liver or nerve poisons. Of chemically related agents, only trichloroethylene can be used with a "fair degree of safety" according to G. R. Glenn. A better choice would be xylene (xylol), although this has the disadvantage of being inflammable. Cyclohexanone has been suggested by Neal, et al.[3] since its effects are not quite as objectionable in increasing the toxicity of D.D.T. It has a peppermint-like odor which aids in identification of the solvent. Kerosense has been more frequently used than any other solvent, but as noted in the attempted suicide reported herewith, it augments the poisonous effect of D.D.T. when the solution is taken accidentally by mouth. In animals we have found the toxic level of kerosene to be doubled when D.D.T. is added in 5-10 per cent amounts.

When oily solvents are used, one should be aware of the risk of skin absorption and be completely familiar with warning signs and symptoms. The most suggestive early indications of D.D.T. poisoning in man are loss of appetite (anorexia) and loss of weight. If exposure is stopped at this point, before muscle weakness and quivering sensations (tremors) develop, complete recovery will result in man and in animals, according to Cameron and Burgess[4]. Liver damage, anemia, increase in number of white blood cells, which occur also, are detectable only when special laboratory tests can be made.

One report by Wigglesworth[5] and one other (not reported) of laboratory D.D.T. poisoning in man indicate that its effects resemble those reported in animals. An acetone solution, containing 25 Gm. of D.D.T. self-applied to the hands and wrists of a laboratory worker was later removed with acetone. Within one to ten days a feeling of heaviness, aching of limbs, weakness in the legs and of extreme nervous tention developed. In both cases bed rest was required because of continuous aching and sleeplessness and anxiety which followed. In one individual tremors (quiverings) of the whole body occurred. Slow recovery followed within 10 weeks, but was still incomplete after one year. In neither case was D.D.T. suspected as a cause of the signs and symptoms exhibited.

When an individual is exposed to a solution believed to contain D.D.T. or accidentally swallows a powder suspected of being D.D.T. a simple field test, devised by the Army, aids in identification.[6] The procedure is: Place in the bottom of a test tube a small amount of the liquid or powder and heat until the contents are charred. With heating HCl fumes are given off which turn moistened blue litmus paper red. If ammonia fumes are brought into contact with the mouth of the test tube a cloud of ammonium chloride forms. Other insecticides containing pyrethrins, fluorides, rotenone and lethane give negative tests. In addition, D.D.T. has a characteristic fine, needle-

3. U. S. Publ. Health Rep., Supplement No. 177.

4. Brit. Med. J., 1: 865 (June 23), 1945

5. Brit. Med. J., 1: 517, (Apr. 14), 1945

6. Bull. U. S. Army Med. Dept., 4: No. 4 (Oct.), 1945

like crystal form and melts at 105.5°C.

The differential diagnosis of D.D.T. poisoning is not easy, unless circumstantial evidence is definite. Recently in the South Pacific approximately thirty people mistook a rodenticide later found to contain thallium for baking powder. One-third of the people died, and the technical and medical personnel in the field assumed that D.D.T. was the causative agent. The signs and symptoms exhibited by the victims closely similated D.D.T. poisoning. Only after chemical examination of the offending substance was the diagnosis established. Table 1 outlines the comparative effects of D.D.T. and thallium poisoning in man. Since the latter is still used to some extent as a rodenticide, similar accidents may occur in the rural areas of California.

TABLE 1

DIFFERENTIAL DIAGNOSIS OF D.D.T. IN POWDER FROM THALLIUM AND COMPARATIVE EFFECTS IN MAN*

D.D.T.	Thallium
Form: Needles, M.P. 105.5°C.	Flame Test: Slight Green.
Fumes positive for chlorine.	Within 24 hours:
Loss of weight due to loss of appetite.	Hyperesthias of fingers and toes make walking impossible.
Persistent aching and weakness of limbs.	Muscle pains in extremities.
Hyperexcitability, generalized tremors and convulsions.	Facial, wrist or foot paralyses occur infrequently.
Laboratory evidence of liver degeneration.	Clonic convulsions, followed by coma.
Rx symptomatic, long acting barbitals and calcium gluconate, 10% solution, intravenously, as needed and use of methionine to protect liver. ‡	No evidence of liver damage.
	Resembles lead poisoning in general.
	Rx symptomatic, 1 and 10% sodium iodide solutions as gastric lavage and intravenous injection, then 10% sodium thiosulfate on subsidence of symptoms. ‡

*In order of their appearance.

‡Consult: Board of Pharmacy, State of California, List of Common Poisons and their Antidotes, Jan. 1, 1946.

Despite the lack of published reports on D.D.T. poisoning in man, two cases ending fatally are known to have occurred in California. One was an itinerant farm worker who was already under the influence of alcohol and who reputedly drank two tumblerfuls of D.D.T. solution and died. The second was an attempted suicide where the individual, a woman of 52, drank about 4 ounces of a D.D.T. mixture in kerosene. After 2 hours she took a soapy mixture in an attempt to vomit. Five hours later severe vomiting occurred and continued over-night. Twenty-four hours after taking the D.D.T. solution shortness of breath was noticed as well as pain on the left side of her neck and left arm. A severe, painful rash appeared on the inner aspects of her thighs and about the genitalia, probably due to excretion of kerosene in the urine. Redness of her mouth and pharynx and pain in the chest and tenderness of the lower abdomen was noticed by the examining physician[7]. There was an increase in the number of white blood cells and her urine contained increasing amounts of albumin. A correct diagnosis of D.D.T. and kerosene poisoning was made and appropriate measures were taken to combat the poisoning. Despite repeated efforts to save the patient, during the ensuing month, she died 33 days later of uremia due to nephritis, believed to be caused by poisoning.

Pathologic examination of this patient's tissues showed an acute exacerbation of a chronic glomerulonephritis with nephrosclerosis, myocardial hypertrophy, pulmonary atelectasis and congestion of the viscera, as well as focal necrosis of the liver[8].

Summary

D.D.T. in powdered form is not likely to afford a hazard to the public provided the material is not inhaled or swallowed in large amounts. In oil or oil miscible solvents, however, its cumulative action and absorbability from the skin provide a definite hazard. Loss of appetite and weight are the first warning signs and if contact is not terminated when they appear, tremors (quivering sensations) may develop and prove serious. Damage to the liver is less obvious but more insidious and together with damage to kidneys and other tissues may cause death.

The differential diagnosis of D.D.T. and thallium poisoning in man is outlined. An attempted suicide, which proved successful, is cited in which kerosene shared responsibility for death of the individual.

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7. I am indebted to Mr. Vernon Silvershield, Coroner of Sonoma County, for the report of the resident physician, Dr. Ronald J. Rolph, Sonoma County Hospital.

8. Report of Dr. Jesse L. Carr, Pathologist to the City and County of San Francisco

Mr. Robinson: Thank you, Professor Anderson.

Are there comments at this time?

Prof. Herms: This group is greatly indebted to Dr. Anderson for this paper. He has come over to us from the Medical School to give us this information. I want to thank him for this very fine paper and to say I am very glad you gave it in just the way you did, Dr. Anderson.

Mr. Gray: I am very appreciative and for a personal reason. He saved me from making a serious mistake in a paper I am to give before the State Medical Association in May.

Maj. Fruitman: In regard to the cases presented. Are they not individuals who are particularly susceptible to the drug? I am thinking of those exposed to it in Europe. Some of our men were exposed to it eight or ten hours a day in spraying. Over a period of two or three months none became ill from the powder or the emulsion. The Army had one man who did develop a dermatitis.

In one of the prison camps in Germany, we had one group of prisoners which broke into a warehouse where the DDT was kept. Not being able to read English, they mistook the material for something else and there were seven dead men as a result.

Dr. Anderson: We have no way of anticipating who will have individual susceptibility. From the standpoint of protecting the public, we have to consider those exposed may be susceptible and I think every reasonable precaution should be taken. If a man is kept engaged in spraying and using kerosene or oil solvent, his hands should be protected with rubber gloves or some sort of protection. Respirators should be used indoors, for it is not well to breathe the material constantly. If the man is careful about washing thoroughly there is little likelihood of any particular danger. In every group there will be those who will take reasonable precautions and those who will not. There will be those very susceptible and those who are not.

Mr. Gray: I hope our Mr. Paxton is listening carefully. He is going to have to use this DDT a lot.

A Member: Is DDT soluble in water?

Mr. Hoskins: DDT dissolves only slightly in water but is soluble in kerosene, fuel oil, xylene and various other things. It can be used effectively in oil solutions and in emulsions. Solvents used in emulsion sprays sometimes temporarily affect paint and may cause shrinkage in certain materials. Xylene dissolves comparatively high percentages of the DDT powder and is quite satisfactory from various standpoints. It does not stain and another point in its favor is that it is not expensive to use. DDT dissolved in Xylene forms a solution. If an emulsion is desired an emulsifier is added to the xylene solution of DDT, and then an emulsion is made by diluting with water. However, xylene is hard on the skin and, as has been brought out, gloves should be worn while mixing the material. It will also cause the eyes to smart, and the fumes may cause sick headaches. There are certain skin lotions or creams which may be applied to protect the skin. But, whatever is used, a good soap bath and clean clothes are both necessary after each day's work.

Mr. Robinson: We had perhaps better leave further discussion of this matter until this evening and go on to the paper which Mr. Gjullin is to read on "DDT Sprays Applied From a Heliocopter Against Adult Mosquitoes."

DDT SPRAYS APPLIED FROM A HELIOCOPTER AGAINST ADULT MOSQUITOES1/

by
Joseph S. Yuill,2/ A. H. Madden,3/ Arthur W. Lindguist,3/ and John R. Mackey,4/

Airplane spraying for the control of adult mosquitoes is a comparitively recent development, which has been made possible largely because of the insecticidal potentialities of DDT. This method of spraying was tested first near Key West, Fla., in November and December 1943, against adults of the salt-marsh mosquito, Aedes taeniorhynchus (Wied.), (Lindquist et al. 1945a). This work was followed in April 1944 by tests against Anopheles albimanus (Wied.) and Mansonia spp. in Panama (Lindquist and McDuffie 1945b). All these tests were conducted with light airplanes. The results stimulated further research by other workers in various parts of the world on the use of several types of fixed-wing aircraft for this purpose.

In August and September 1945 the writers conducted an extensive series of tests to obtain information on the effect of such factors as time of application and concentration of DDT sprays applied from the air against adult mosquitoes. A helicopter was chosen for these investigations, because (1) it could operate from a small cleared space adjacent to the test plots, thus reducing the time between comparative treatments, (2) the spraying apparatus permitted a wider range of atomization than did available airplane equipment, and

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1/ This work is a part of a part of a combined project of the U. S. Bureau of Entomology and Plant Quarantine; the Bureau of Medicine and Surgery, U. S. Navy; and the U. S. Coast Guard. The advice and suggestions of E. F. Knipling and the assistance of Bernard Knecht, Fred Shilcutt, and Douglass Burnett, Jr., are acknowledged.

2/ Lt Commander H(S) USNR.

3/ Entomologist, U. S. D. A., Agr. Res. Adm., Bureau of Entomology and Plant Quarantine, working under a transfer of funds, recommended by the Committee on Medical Research, from the Office of Scientific Research and Development.

4/ Lieutenant (j.g.), USCG.

(3) its maneuverability and wide range of visibility permitted a more uniform application of spray than is usually possible with an airplane. This represents the first known use of a helicopter in experiments on the control of adult mosquitoes. It should be pointed out that with this type of aircraft the distribution of spray through a forest canopy may differ from that obtained with a light airplane. The stronger downward movement of airflow from a helicopter has been noted, but the effect on the spray has not been determined.

DESCRIPTION OF TEST AREA

The tests were conducted in a low, level, somewhat swampy area along the west bank of Mosquito Lagoon near New Smyrna, Fla. A series of plots approximately 50 acres in size were established in this area. About two-thirds of each plot was covered with mixed hardwoods and cabbage palms, varying in height from 40 to 60 feet, with a fairly dense canopy, but with little undergrowth. The remaining third was covered with a thin stand of pine trees. The pine stands were included in the plots to complete the desired acreage. Migration of mosquitoes from contiguous untreated areas often obscures the results obtained in smaller plots. Observations on the relative effectiveness of the various treatments were confined to that portion of the plots covered by the heavy growth.

The mosquito population consisted mainly of the salt-marsh species Aedes taeniorhynchus and A. sollicitans (Walk). At times there were also a few fresh-water breeders (Psorophora spp.). Considerable fluctuation in abundance occurred in different plots because of the distance from the principal salt-marsh breeding areas, late seasonal lags between broods and weather conditions. However this fluctuation had no effect on any of the records except the 24-hour counts.

EQUIPMENT AND METHODS

The aircraft used in these investigations was a Sikorsky, Coast Guard HNS-1 (Army R4B) helicopter. This is a 200-horsepower ship with a total useful load of 506.5 pounds permitting a new allowance of 127 pounds for spray material. Its cruising speed is 50 to 60 miles per hour.

The spraying equipment consisted of a series of nozzles mounted on a 9-foot boom suspended 18 inches below the rear portion of the fuselage. Placing the equipment in this position protects the fuselage and tail section from the spray. A simple pressure system was used operated by a hydraulic pump (Vickers model PF271325ECE) driven directly by the engine of the helicopter. The pressure was controlled by a relief valve and bypass line through which the spray material was returned to the tank when the nozzles were not in operation. The bypass line, the line between the tank and the pump, and the discharge line were of 3/8-inch tubing. A more uniform flow could be obtained by installing larger tubing particularly in the bypass line. Some reduction in pressure surges was obtained by installing a second relief valve, set at 200 pounds per square inch, in the discharge line just forward of the nozzle boom.

Two types of nozzles were used, a fern-type nozzle with a 55-wire-gage orifice and a TT8001 with a 0.020-inch slotted orifice. The former delivers a discoid or parasol-shaped spray with coarse droplets and the latter a flat spray with fine droplets. A pressure of 75 pounds per square inch was used with the fern nozzles, and a pressure of 150 pounds with the TT8001 nozzles.

A number of preliminary tests were conducted over open ground to determine the discharge rates of the two types of nozzles and the droplet spectra of the atomized sprays. The helicopter was flown at cruising speed, with the equipment discharging the spray mixtures chosen for these investigations. The following mixtures were used: (1) 5 per cent of DDT in a mixture of 80 per cent of No. 2 fuel oil and 20 per cent of No. 30 lubricating oil and (2) 20 per cent of DDT in a mixture of 50 per cent of PD-544C solvent (an aromatic petroleum fraction), 30 per cent of No. 2 fuel oil, and 20 per cent of No. 30 lubricating oil. Discharge rates were determined by flying cross wind and spraying for a timed period (60 or 120 seconds). The amount delivered was obtained by measuring the amount of material placed in the tank and the amount remaining after spraying. These measurements were made to within 0.1 gallon. In determining droplet spectra the flight was made into the wind. Samples were obtained by passing a treated glass slide through the falling spray as the helicopter flew directly overhead. All determinations were made in duplicate.

It was found that 17 TT8001 or 5 fern nozzles were needed with the 5 per cent DDT solution, and 5 TT8001 or 2 fern nozzles with the 20 per cent solution, to give a constant dosage of 0.2 pound of DDT per acre. Although dosage was known to be below that needed for practical control, it was selected purposely so that comparisons between treatments could be obtained. In terms of total material, the dosage was 2 quarts per acre with the 5 per cent solution and 1 pint per acre with the 20 per cent solution.

Data on droplet spectra obtained with the 5 per cent solution are presented in figure 1. It will be noted that there was some overlapping of droplet sizes in the fine and coarse sprays. In general about 80 per cent of the droplets (by number) in the fine spray were below 100 microns in diameter, whereas about 90 per cent of the droplets in the coarse spray were below 300 microns and 40 per cent were above 100 microns. Findings with the 20 per cent solution were almost identical.

The treatments were applied to the test plots by flying the helicopter in an easterly and westerly direction, which was approximately cross wind in most cases. The swath width was 60 feet, and the flight pattern was always started on the proper side of each plot so that turns at the ends of the swaths would be into the wind rather than downwind. The plots were of such a width that 20 swaths constituted a complete treatment. Applications were made at normal cruising speed from an altitude of 30 to 35 feet above the canopy. Since the area lies between the water and a paved highway, it is well defined from the air. The western corners of the plots were marked by white flags fastened in the tops of trees, and an additional flag was placed.

midway between the corners. Flags form rather satisfactory markers, but their installation is very slow and laborious.

A series of meteorological data including temperature, relative humidity, wind direction and velocity and lapse rate, were obtained in the open near the edge of the plot during the application of each treatment. Lapse rate means the difference between temperatures taken at 2 and 0.3 meters above the ground, and represents a measure of the stability of the surface layer of the atmosphere. A positive lapse rate indicates inversion, whereas a negative lapse rate indicates convection. The latter condition tends to prevent the smaller spray droplets from reaching the ground.

The results of each test were evaluated by making a mosquito count within the treated plots before spraying and 2, 6, and 24 hours thereafter. Each observer counted the number of mosquitoes alighting on all visible portions of his clothing during a 1-minute interval. This method is discussed in some detail by Lindquist et al. (1945). Twenty counts were made over a wide area in each plot at each observation period. The same positions or counting stations were used on each occasion. The difference between the number of mosquitoes in a plot before and after treatment was used as the basis for calculating the percentage control. Additional counts were made in untreated check areas from time to time to obtain information on natural fluctuations in abundance.

EFFECT OF TIME OF APPLICATION

In one series of tests with the 5 per cent DDT solution the effectiveness of applications at different times of the day was compared. Both types of nozzles were used. All treatments in each replication were applied on the same day.

In general the meteorological conditions which varied with the time of day, had little effect on the results. Under the most unfavorable lapse rates and highest wind velocities the control was equal to or better than that obtained under favorable lapse rates and no wind, with one exception. In another series of tests, with fine and coarse droplets at midday, the sprays were applied under a combination of the highest wind velocity and the most unfavorable lapse rate recorded. With both sprays the degree of control was very low although not below average with the coarse droplets. Wind velocity, which must have been at least 15 miles per hour above the forest canopy (readings were taken at 6 feet), appeared to be more important than lapse rate. It could be seen that the spray was being driven downwind for a long distance, and probably many of the droplets were lost or deposited on the upper foliage.

Wind direction and relative humidity apparently had no appreciable effect on control. Fluctuations in meteorological factors probably affected the sprays only while they were above the canopy, since it has been found that within the jungle such factors are practically constant throughout the day.

The conditions of this experiment and the results are summarized in table 1. There was considerable difference in lapse rate, wind velocity, and relative humidity between dawn and midday applications. To determine the significance of these differences an analysis of variance was made of the 2- and 6-hour records.

Analysis of the 2-hour counts is given below:

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Sq.
Between tests	4	4402.3	1100.575
Between treatments	3	4552.8	1517.600
Error	12	2589.7	215.808
Total	19	11544.8	

The F value for difference between treatments is 7.03, which is highly significant. With the formula used (Wadley 1943) a generalized standard error of difference was calculated. By this means it was found that the least difference between means requires for significance was 21.4 at the 5 per cent level and 31.2 at the 1 per cent level. The application of these values shows:

(1) No significant difference between fine droplets at dawn and fine droplets at midday.

(2) A highly significant difference between coarse droplets at dawn and coarse droplets at midday, the former being the more effective.

(3) No significant difference between fine droplets at dawn and coarse droplets at dawn.

(4) Significant difference between fine droplets at midday and coarse droplets at midday, the former being the more effective.

Table 1.—Control of adult mosquitoes with sprays containing 5 per cent of DDT when applied from a helicopter at different times of day.

Time of Application	Size of Droplets	Temperature	Lapse Rate	Wind Velocity	Rel. Hum.	Control in — 2 hrs.	6 hrs.	24 hrs.
		°F	°F	M.p.h.	%	%	%	%
Dawn	Fine	76	±0.29	1.1	100	75	72	35
	Coarse	77	-0.32	0.9	97	68	64	61
Midday	Fine	86	-2.70	3.6	75	60	56	49
	Coarse	87	-2.34	3.5	76	35	41	44

Analysis of the 6-hour counts showed that there was no real difference in effectiveness between the treatments. This apparently was due to delayed action (residual or otherwise) of the coarse sprays.

No attempt was made to analyze the data obtained from the 24-hour counts, since these data appeared to be somewhat biased owing to unequal migration of mosquitoes into the plots. The data indicated, however, that no real differences could be demonstrated by analysis.

For comparative purposes two series of tests were conducted on the same plots earlier in the season with a Stearman PT-17 airplane. A 5 per cent DDT solution was applied at the same dosage as that used in the helicopter tests. The average results are shown in table 2.

Table 2.--Control of adult mosquitoes with sprays containing 5 per cent of DDT when applied from a Stearman PT-17 airplane at different times of day.

Time of Application	Size of Droplets	Control in 2 Hours	Control in 24 Hours
		Per Cent	Per Cent
Dawn	Fine	56	22
	Coarse	51	42
Midday	Fine	46	43
	Coarse	51	42

These data also indicate no significant differences between treatments, but the results are not considered conclusive because of the limited number of replications. The control was slightly less than that obtained in most cases with the helicopter.

EFFECT OF CONCENTRATION OF DDT

In another experiment the relative effectiveness of 5 and 20 per cent DDT solutions was studied. In this series also a comparison was made between fine and coarse sprays. The tests were paired in each case with respect to the concentration of DDT, but time did not permit consistently paired applications of fine and coarse droplets.

A summary of the data is presented in table 3. Meteorological conditions were constant, but this is to be expected as the treatments were not confined to dawn and midday periods as in the previous tests. There was little difference in results between treatments at 2, 6, or 24 hours after application. The data were not analyzed statistically, since it appears evident from an inspection of the records that no real differences exist.

Table 3.-- Control of adult mosquitoes with sprays containing 5 and 20 per cent of DDT when applied from a helicopter.

Concentration of DDT	Size of Droplets	Temperature	Lapse Rate	Wind Velocity	Rel. Hum.	Control in — 2 hrs.	6 hrs.	24 hrs.
Per Cent		°F	°F	M.p.h.	%	%	%	%
5	Fine	76	-0.18	1.2	86	71	70	66
	Coarse	79	-0.32	1.4	84	64	66	64
20	Fine	78	-0.36	1.9	84	58	66	66
	Coarse	79	-0.86	1.0	84	59	73	68

Conclusions.--Under the conditions of these experiments, neither time of application nor size of spray droplets had any effect on the degree of control of adult mosquitoes, although the immediate results obtained with a coarse spray applied at midday were lower than with the other applications. It is possible that more pronounced differences would have been apparent if sprays with a wider difference in particle size had been compared. However, the droplet sizes used represent a close approximation of those ordinarily used in practice. These tests should be repeated with other types of aircraft.

When applied at the same dosage of DDT, 20 per cent solutions were just as effective as 5 per cent solutions. This makes it possible to increase the area covered per load of spray by four times without reducing the effectiveness of the treatments. The practical importance of this factor in improving the usefulness of aerial spraying against adult mosquitoes is apparent.

Although the helicopter is considered to be a desirable tool for experimental work, the model used in these experiments would not be practical for routine control operations, for the following reasons: (1) The useful load is limited; (2) power for operating in restricted situations during hot, humid weather is inadequate; (3) pilot fatigue is excessive owing in part to vibration and power limitation of the plane; (4) the blades tend to warp when exposed to rain or heavy dew; (5) purchase and maintenance costs are high. Further development of the helicopter, it is believed, will tend to eliminate most or all of these objections.

Summary.--Tests were conducted near New Smyrna, Florida, with DDT sprays applied by a helicopter against salt-marsh mosquitoes, Aedes taeniorhynchus (Wied.) and A. sollicitans (Walk.), for the purpose of determining the effect of time of application and concentration of DDT on the results of the treatments. Two types of nozzles were used, one of which delivered a spray with coarse droplets and the other a spray with fine droplets. It was found that treatments applied at midday were just as effective as treatments applied at dawn, except that lower immediate results were obtained with coarse particles applied at midday. In general, particle size had no effect on results. When applied at the same dosage rate of DDT per acre, a 20 per cent solution was just as effective as a 5 per cent solution. The area treated per load of spray can therefore be increased four times without any reduction in the effectiveness of the treatment. The helicopter used in these tests is not considered practical for routine control work, but further developments in this type of aircraft probably will permit the satisfactory use for this purpose.

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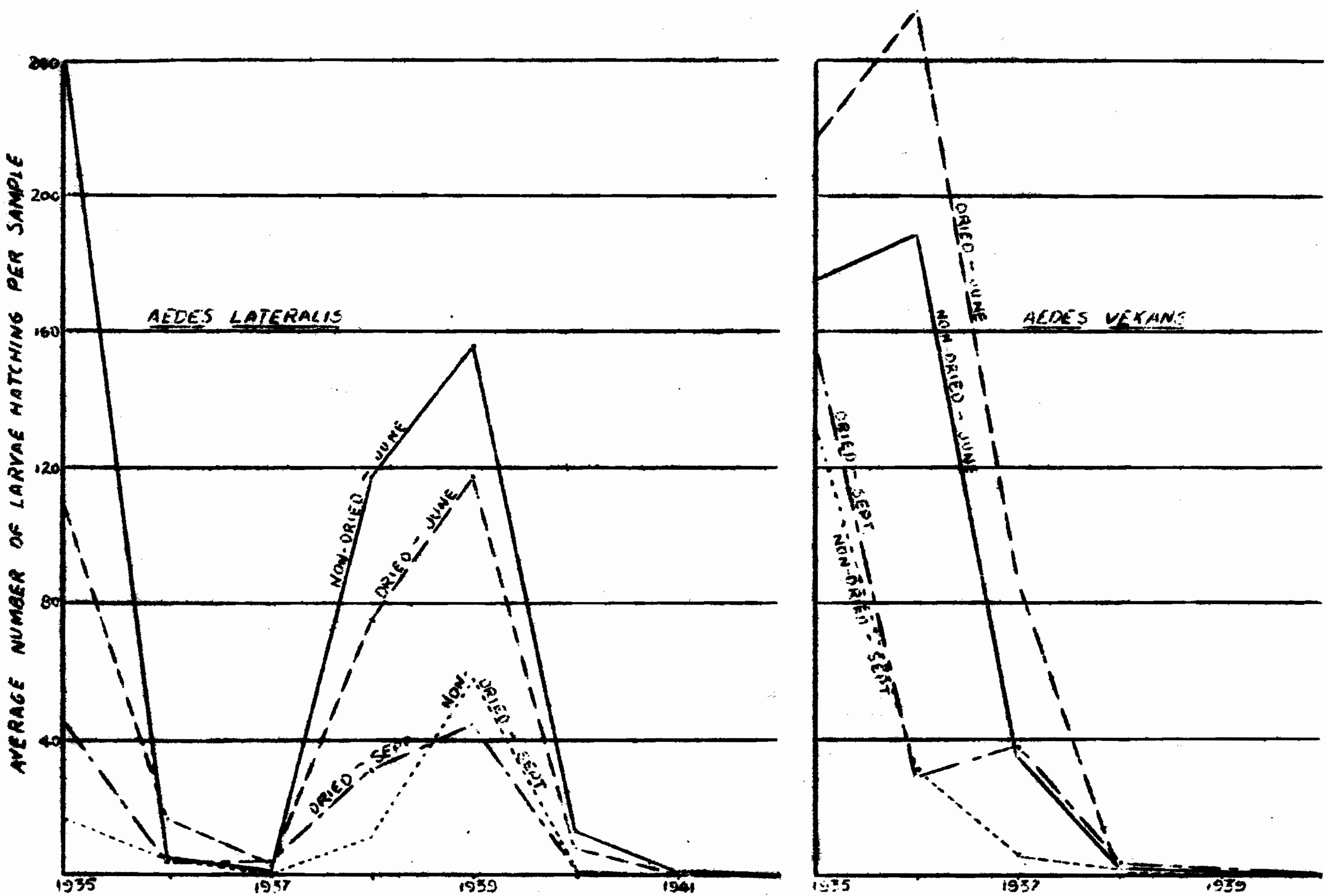

Figure 1. Average hatch of Aedes lateralis and A. vexans eggs per sample from 12 samples of soil taken in June and September of each year. Half the samples were dried before being flooded, and the other half were not dried.

Mr. Gray: I think we will have to buy one of those contraptions. Fred Hayes was very much interested in the helicopter, and talked at our last meeting* about its possible application to mosquito control work. I am glad to get information about some of the limitations of the helicopter.

Mr. Robinson: Don Reese from Salt Lake City is here. I would like to have him give us a little of his observations of what they did at Salt Lake City.

Mr. Reese: I am sorry but we haven't been using it for experimental work. My information is very limited so I am not able to give much additional information. We hope next season to use it more extensively and we will profit by the information received here. So far we have used it only on small areas and in a few ornamental pools. There has been nothing very extensive.

Mr. Robinson: Art Geib, recently appointed Superintendent of the Dr. Morris District, has something for us on "Some Observations of Airplane Application of DDT Dust as a Larvicide."

Mr. Geib: My information regarding the DDT work done at Bakersfield this past fall is second-hand. I was not there at the time. Therefore I am not in a position to give any detailed data regarding that work. However, I can generalize and tell you what occurred.

Last fall the District annexed a considerable area. South of the city was a duck hunting club area. The then Superintendent was quite ill and his foreman carried on. In September, the duck clubs were flooded and then the situation of course became a matter of urgence so far as the temporary superintendent was concerned in order to stop the anticipated mosquitoes from emerging.

The water depth ranged from one inch to several feet. It was impossible for him to attempt to control the Aedes dorsalis by the method he had been using, namely oil application with power equipment. So he made contact with a local dust firm and was able to obtain DDT in talc. He was much discouraged over the fact that they might get away from him so he did not attempt any trials or experimental work but used 15% DDT dust in talc applied with a plane of about 220 h.p. carrying a 600 lb. load. The dust was applied at the rate of 2½ lbs. per acre. Some of the water was quite clear with no vegetation. Other water was heaving overgrown with plants. After application -- immediately after or within an hour or so, there was a milky appearance in the water due to the amount of talc applied. Dipping was undertaken immediately within a few hours and again several days later. Aedes dorsalis breeding had been quite heavy. The day following the dusting no larvae could be found. That condition existed for some eight or nine weeks after that. I have not been able to get any detailed information so it is hard to say whether there was a real residual effect or whether there was no subsequent breeding because of climatic conditions.

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*Proceedings and Papers of the Thirteenth Annual Meeting of the California Mosquito Control Association, February 28-29, 1944, pp. 91-93.

The work that the existing superintendent did with the airplane was so satisfactory that we are anticipating further use of airplane application this coming season both for spray and dust application, not only in duck club areas but also along the river which produces tremendous quantities of Aedes vexans.

In general, the cost of operations last fall were too expensive to be undertaken under normal operating conditions. The actual cost was $3.75 per acre for the plane. The total cost of flying DDT was four to six dollars per acre. We are hopeful that spray applications with smaller quantities of DDT will reduce the cost to where it will be more practical.

Mr. Gray: Was there any check up made on the duck clubs during the duck season?

Mr. Geib: Very little breeding appeared in the ponds. After the season was concluded they said they were very happy at the clubs as they had been free of mosquitoes during the hunting season.

Mr. Robinson: How long before the shooting season did you spray?

Mr. Geib: We began the middle of September and continued it over different acreages until approximately the middle of October.

Mr. Gray: We have in Alameda County quite a few duck clubs and get along pretty well with them. One of them is a club which has been rather difficult to control because they have a very poor pump capacity -- only 700 gals. p.m. -- so they flood very slowly. They begin about the first of August and pump on to land which has a very heavy growth of grass. As the water rises slowly, dorsalis hatch along the edges of the rising water. Heretofore these have been controlled irregularly and not too satisfactorily by spraying with kerosene emulsion or kerosene-pyrethrum. When DDT became available, I got the idea that by using it in dissolved form we would be able to control the hatching of the Aedes dorsalis. We set up a barrel with a drip calibrated so we would get approximately one part DDT to 10 or 20 million, and applied it to the incoming water from the pump. The results were completely negative. In the open ponds where we get very little breeding anyway, we had no breeding. In the grassy areas the results were spotty. We had trouble with the continuous dosing scheme clogging with DDT crystals apparently coming out of the emulsion. Prof. Freeborn told me of some experimental work in rice fields where it appeared as if much vegetation removes the crystals of DDT from water and therefore it becomes ineffective. We found that after the water worked its way out through the grass the hatching went on without any diminution over the normal hatch, and we had no control whatever. Finally, we went back to kerosene, pyrethrum and emulsifiers and got pretty good results. (we still have some pyrethrum concentrate.) I am at present uncertain whether the fault is with the emulsifier, with the zylene solvent, or whether some action of the vegetation or possibly some other physical factor removes DDT so it does not affect the larvae. They seem to have gone on and pupated and emerged in spite of the application of relatively large quantities of DDT. We are going to try again next year and change the set-up and take time to study it. I have hopes that using DDT as a wettable powder may accomplish something. We plan to try using the DDT as a wettable powder and see whether that will work instead of dispersing in an organic solvent. But it doesn't work in the presence of a great deal of vegetation, we find. This corresponds to some work in the rice fields in Texas where the material was used in the same way and they got pretty good kill close to the point where the DDT entered the rice fields, but further and further away they got practically nothing in the way of control. If we could find some way of introducing it into the water that is used for flooding, that might be the answer. It would certainly save us a lot of work where we haven't an airplane. In this area there is a very high voltage electric power line which would not make the use of a plane feasible.

Prof. Herms: Dr. Eckert asked me to inform this group that when you are going to do DDT dusting by airplane, and work of that sort, you will probably have to square yourselves at times with the agricultural commission and also with the bee inspector. He said too that if you could notify him he will try to help you.

Mr. Robinson: In Modesto we wanted to do quite extensive work. Our Country Agricultural Commissioner gave us about three miles along the river for experimental purposes. We got very good results in that area. We put 6 bee hives in the line of flight and after two or three days dead bees were brought up to Sacramento for examination. We got a clean bill of health from the State on that operation. About two or three weeks afterwards I was told to go ahead but by that time the vexans had gone on.

The next paper appears to be my own. I was asked to give one on "DDT Control of Mosquito Breeding in Irrigation Canals and Sewer Farms.

DDT CONTROL OF MOSQUITO BREEDING IN IRRIGATION CANALS AND SEWER FARMS

By

E. Chester Robinson

In our preliminary experiments with DDT in irrigation canals our aim was to find some method of impregnating the water in the canals in order that the residual effect would last long enough to kill the larva that hatched after the water was applied to the field. So far we have noted little or no effect from this method from concentrations that were economically feasible.

In one instance where we applied a drip system to a private ditch carrying 35 second feet of water and where the head gates to the checks were overflow type, we received excellent results with the following solution: 23 gallons diesel oil - 2¼ gallons of 25% non-emulsible DDT and 2 tablespoons B1956 spreader per gallon. This solution was placed in a steel drum and ran into the ditch at the rate of 7 gallons per hour for 3 hours, while irrigating 20 acres of pasture grass. On this experiment we received at least 98% control.

Other experiments were conducted with emulsified DDT and water and emulsified DDT and oil, at the rate of 1 to 80 to 100 million by weight where the water went through small outlets below the surface of the canal. In these experiments the results were not satisfactory.

In applying DDT to main irrigation canals several methods and solutions were used, all of which were very satisfactory. On May 5, 1945 in the Modesto Irrigation District's main canal, flowing 640 second feet per minute, we used 2 gallons emulsified DDT - 6 gallons diesel oil - applied at the rate of 2 gallons every 20 minutes. Two days later no larva were found present in 100 miles of irrigation canals where before we could get from 3 to 17 Anopholene freeborni per dip.

On June 22 there was 920 second feet going over the weir. We used two gallons of 25% DDT to 15 gallons of water at the rate of approximately 4 gallons every 15 minutes. Larva present before application, 3 to 11 per dip, larva present 2 days after application total in 150 dips 4 pupa and 1 larva. July 17 there was 860 second feet going over the weir. We used 2 gallons emulsible DDT to 10 gallons diesel oil. Approximately the same number of larva was present before application. July 28 there was 1020 second feet going over the weir. With only three gallons of emulsible 25% DDT with three gallons of water, 2 quarts of this solution was put in every 15 minutes. Because of excessive weed growth on the banks of the canals this operation was only 100% effective for a distance of 4 miles. On July 30 - 5 gallons emulsified DDT mixed with 20 gallons diesel oil was applied again and at the rate of 5 gallons every 15 minutes. This completely corrected the failure of the previous application. August 24 there was 605 second feet going over the weir. We used 5 gallons of 25% non-emulsible DDT, 10 oz. B-1956 spreader mixed with 20 gallons of water. This solution was put in a sprinkling can and slowly poured into the main canal, taking a total elapsed time of one and one-half hours. The kill with this solution was as good as with any of the others used. The reason for the increase in the amount of DDT was, although the flow in second feet had been reduced, there was an excessive growth of water grass along the canals, sometimes extending out into the main canals for a distance of six or seven feet on each side. This operation would require three or four thousand gallons of diesel oil and several men and a large spray rig for at least a week. Some of the canal banks have no roads and would have to be sprayed by hand. In all of these experiments the total elapsed time of application was not over one and three-quarters hours. No appreciable kill of larva was noticed in any of the fields that were irrigated during the time of application.

The Riverbank sewer farm takes care of the city of Riverbank, with a population of 1,500 and the Santa Fe Railroad's round house terminal shops and the Riverbank Canning Company. To start with we applied 8 ounces of 25% emulsified DDT in the main pipe line per day. Later we reduced this to 8 ounces every third day until the cannery was operating two shifts, at which time we applied one pint every third day. This has completely eliminated the necessity for spraying this sewer farm which normally took from 75 to 100 gallons of diesel oil every week or ten days.

The Escalon sewer farm takes care of the city of Escalon, with a population of 2,000, a cannery and a winery. This sewer farm consists of evaporating ponds with an area of from one to four acres per pond. Here we sprayed around the edges with a solution of 2 quarts of 25% emulsified DDT with 20 gallons of water and had the same control as would have been obtained with the use of 60 gallons of diesel oil and saved about one-fourth the time of application.

Mr. Gray: Do you consider that vegetation interferes with the effect of the DDT?

Mr. Robinson: I think that there is a certain amount of absorption by the soil, and that vegetation finally kills the effectiveness of the DDT.

Prof. Herms: I would like to ask Prof. Freeborn where he has anything on that matter of absorption.

Dr. Freeborn: The problem is principally in the soil. You will get good control in the irrigation ditches that are lined with concrete. You can mix DDT with several kinds of soil and it is not effective. In Georgia that was done over and over again. We need to know much more about this. In Arkansas they dusted the fields with DDT dust before putting the water in the rice fields and had no results. There was no appreciable result when it was put in the irrigation water and distributed. Always it was ineffective when connected with any turbulence of water. But if the DDT is mixed with oil so that it stays at the water surface it remains effective.

Mr. Robinson: That bears out our experiment. The oil held it on the water surface.

Dr. Freeborn: We ran tests on application in the water on the rice and it did no damage. DDT in oil was used. We scattered it on to the paddies and there were no bad effects.

Mr. Robinson: It seems to take very little of the DDT.

A Member: Yes, as a larvicide it is effective in killing larvae and pupae in very low dilutions.

Dr. Freeborn: About one part of the DDT in 30,000,000 parts of water seems to be right under field conditions.

A Member: I want to ask a question about flow in the canals. Was the flow such that it was practically dead water? How much effect would be due to the fact that there was no movement in the water?

Mr. Robinson: The water in the canals ran at the rate of about 2½ miles per hour. It slowed down where there was much vegetation to about 1/2 to 1½ miles per hour.

A Member: In your district do irrigation canals constitute an important problem?

Mr. Robinson: Probably about 90% of the anopheles breed along the banks of canals. In the fields themselves, the mosquitoes present are primarily dorsalis.

Mr. Robinson: Perhaps we'd better get on now to the paper which Bill Reeves has for us on the "Application of DDT Residual Spray for Adult Mosquito Control."

APPLICATION OF DDT RESIDUAL SPRAY FOR ADULT MOSQUITO CONTROL

By
William C. Reeves, Ph.D.
George Williams Hooper Foundation
University of California
San Francisco

During the past year, as a part of our field investigations, in Kern County on the epidemiology of encephalitis, studies were made on the use of DDT residual sprays for the control of adult Culex mosquitoes. This program was a cooperative project of the State Health Department, M.C.W.A. of the United States Public Health Service, and the Hooper Foundation. I would like to briefly summarize some of the problems we encountered in the application of residual DDT deposits for adult mosquito control, and point out some of the advantages of this method of control for application to certain of your field problems.

The techniques used in this study were based on the methods recommended in the United States Public health Service and United States Bureau of Entomology Bulletins with which you should be familiar.

All applications were made with portable hand sprayers of the Meyer's Kiwkfill type. This model of sprayer is now available, and has the advantages that it is easily carried and operated by one man; also it can be handled in inaccesible places.

Several types of DDT sprays were used in this study and they varied enormously in their effectiveness. Certain definite disadvantages were found in the use of 2.5 or 5.0 per cent DDT in solution in No. 2 diesel oil. Diesel oil is a very cheap carrier for the DDT but when applied to dry unpainted wood surfaces the oil quickly soaks into the wood carrying the DDT with it and leaves a very light, ineffective, residual surface deposit. As a large proportion of buildings other than homes are made of rough unpainted wood poor results are obtained. The same objection might be raised to the use of any oil carrier on such surfaces. On finished surfaces there is the additional objection that diesel oil stains, Several of the workers developed a dermatitis from prolonged exposure to the oil, and when working in closed buildings during the hot summer months this objection alone is sufficient reason for not using oil solvents for this purpose.

In our studies the best results were obtained by using a quick breaking, xylene-water emulsion of 2.5 or 5 per cent DDT. Because of the quick breaking characteristics of such an emulsion and the volatility of xylene good surface deposits of crystalline DDT were obtained, even on the roughest and driest of wood. No skin reactions were noted in the men applying this material even during the hot summer months.

In treating the interior of buildings, which were serving as resting places for adult mosquitoes, we found it essential to have as complete a coverage as could be obtained of all surfaces within those buildings. In making checks of treated buildings large numbers of Culex 5-fasciatus and Culex tarsalis could frequently be found in untreated niches such as nests, boxes, piles of junk, upper surface of rafters, etc. This presents a problem as these inaccessible places which are favorite resting places for the mosquitoes are also the areas in which it is most difficult to obtain good spray coverage. It is essential to impress on laborers that such places must receive particular attention and while they are learning this technique their work must be checked. It is not satisfactory to merely send a man out with instructions to spray a building. The method of application he is to use should be carefully demonstrated, with certain standards set up, and a complete explanation should be made of the reasons why complete coverage is necessary.

For economy of man power and material a preliminary inspection of buildings for adult mosquitoes is essential to determine which shelters should be treated, and periodical recheck should be made to determine if respraying is required to pick up spots which have been missed. This method will result in a marked reduction of Culex adults in domestic shelters. With careful coverage we obtained better than a 90 per cent reduction of Culex mosquitoes resting in treated shelters.

There are situations in which you will find this type of treatment is useful as a routine mosquito abatement practice. As you all know, when a person living in your district calls in and complains of mosquitoes around their home they expect immediate action and results. Successful elimination of larval breeding does not give immediate reduction in the number of adult mosquitoes and this frequently leads to additional and bitter complaints. In many situations you will find that careful application of DDT residual deposits in the adult resting places on such premises will give immediate relief and will allow time for larval control measures to take effect.

In certain places where you anticipate an adult problem and are incapable of preventing an influx of adults, it is possible to apply residual deposits before the problem has become acute.

A new tool is now available to you and the uses to which it has been put are still limited. However, there is no limitation in the origination of new techniques for the use of DDT which you, as practical field men, may conceive and develop.

Mr. Robinson: There is one more paper this afternoon -- that of Harold Gray. He will tell us something about DDT Control of Mosquito Breeding in Catch Basins and Underground Vaults.

THE CONTROL OF MOSQUITO BREEDING
IN STREET INLETS (CATCH BASINS),
UNDERGROUND UTILITY VAULTS AND
SIMILAR STRUCTURES, BY DDT RESIDUAL SPRAYS

By
Harold F. Gray, Engineer
Alameda County
Mosquito Abatement District

In the planned division of practical field studies of DDT agreed upon in 1945 between Mr. Hayes, Mr. Robinson and the speaker, certain studies were assigned to the Alameda County Mosquito Abatement District. These were principally urban in type, and related to various structures in which mosquito breeding occurs, such as street inlets for storm water, the underground vaults of the public utilities, and similar structures.

In June of 1945 we obtained from Chemurgic Corporation a sufficient supply of 25% DDT emulsion and solution to begin operations. Six utility vaults were selected and sprayed with a 2½% emulsion on June 9, and the water in an additional vault was treated with phenothiazine for comparison. In four vaults the walls and ceilings were sprayed; in two vaults the water only was sprayed with DDT. Each of the vaults selected had in past years been a prolific mosquito breeder requiring frequent oiling.

In addition, between June 6 and June 12 we sprayed 800 street inlets with 2½% DDT dissolved in Diesel oil, applying the material to the side walls for residual effect.

Inspections of the utilities vaults indicate that the DDT spraying was effective in preventing mosquito breeding down to the beginning of colder weather in November. For the same period, inspections of the 800 street inlets sprayed with DDT showed a remarkable reduction in mosquito breeding, although larvae were found in a very few cases. No mosquito breeding occurred in the vault treated with phenothiazine.

From June 15th to mid-October 9770 sprayings of street inlets with DDT (10 lbs. dry technical grade in 50 gallons of Diesel oil -- about a 2½% solution) were made, but with no attempt to cover the sidewalls completely. Exact numerical counts on re-inspections of this series were not made, but our general observation was that while an appreciable improvement resulted, much better results were obtained from the first series of 800 street inlets where the sidewalls were completely sprayed.

A series of 243 cesspools was sprayed in mid-August with DDT in Diesel oil (10 lbs. to 50 gallons), applying it heavily to the sidewalls and ceiling. Inspections made later, running down to the end og October, showed no breeding within the cesspools, but s ome larvae occurred in the overflow from four cesspools.

In addition, we have applied DDT as a residual spray to a wide variety of structures which were either heavy breeders, such as certain storm sewers (one nearly a mile long), or were day-time shelters for adults, such as the under sides of small bridges and road culverts. A sufficient time has elapsed in some of these cases to indicate to us that DDT residual spray is a very effective means for at least partially reducing, and in some cases, entirely eliminating mosquito harborage for at least several months.

Adequate quantities of DDT for extensive field trials were not obtainable during 1945, but will be available for our 1946 campaign. On the basis of our observations in 1945, we expect that one systematic spraying of the underground street vaults of the public utilities, made in April and May, will probably prevent breeding until about October, if not longer. We are now endeavoring to make arrangements with the utilities for such a cooperative project.

Beginning about May 1st we intend to thoroughly spray all the street inlets (catch basins) in the metropolitan area. We expect this will be effective for three momths in perhaps 90% or more of the cases, but the remainder may need additional sprayings because of special circumstances. A general re-spraying will probably be needed in August.

We expect also to spray the walls and ceilings of all our larger storm sewers and covered drains, and the undersides of small bridges and larger road culverts, which are favored day-time shelters for adult mosquitoes. In addition, we expect to spray all cesspools in the district probably twice during the season.

In all of these uses we intend to use a 2½% (approximately) solution of DDT in Diesel oil, as this appears to be the simplest and cheapest method of application at present available. The solution is to be sprayed on the interior surfaces of the structures for its residual effect on the adult mosquitoes which alight there. We do not expect to use DDT to any great extent as a larvicide, though we will use it experimentally to determine relative costs and efficiency as compared with oil, phenothiazine and pyrethrum.

For situations where wall discoloration by Diesel oil will be objectionable, we will use the standard Xylene-emulsifier mixture. We have set up at our Oakland depot an apparatus, operated by an electric motor driven pump, for the preparation of DDT emulsions and solutions.

During 1946 we expect to try out DDT wettable powder in comparison with DDT solutions and emulsions. Applied as a residual spray in this form, it may have certain advantages. We also have hopes of obtaining sufficient supplies of "DDD" and of "666" for comparative field tests.

At this time we are not prepared to make any statement as to relative costs of using DDT under our conditions. We do feel optimistic that its use in appropriate places will result in obvious improvement in control effectiveness, and we intend to use it to the fullest extent possible during 1946, and then assess effectiveness and comparative costs on the basis of an entire season's work.

Prof. Herms: What is your reason for delaying until May 1st?

Mr. Gray: It is a question of rainfall. On the street catch basins and, to a certain extent, on street vaults, while we have the rains the use of DDT would probably be somewhat interfered with. It would be washed away. After mid-April or early May when we have no rain or at least very slight rains, is the best time to begin DDT application.

Prof. Herms: Thank you. I just wanted that point brought out; I thought perhaps it was not quite clear to everybody.

Mr. Bendel: Is it necessary to have agitators on the sprayers?

Mr. Robinson: Not unless there is a low temperature. Hot weather makes a difference. The movement of the trucks is usually enough to keep the emulsions stirred up.

Mr. Menefee: When knocking around they get a lot of agitation. Walking around with one of these knapsack sprayers there is bound to be a lot of agitation.

Mr. Russell: When do you spray cesspools?

Mr. Gray: Cesspools are taken care of from March to October. Many are open all the time. Breeding occurs mostly during the summer months, though there is some winter breeding.

Mr. Russell: People in our district close their own cesspools up.

Mr. Gray: We tried to work that out. I maintain that open cesspools are primarily a public health department's problem, and the health department is primarily responsible for the abatement of these nuisances. I refuse to pull the County Health Department's chestnuts out of the fire. When we can get some working arrangement by which they will take their share of the enforcement program we will be willing to file nuisance complaints cooperatively.

Mr. Russell: We try to show consideration to our people and to give good value for their money, but the property owner has a responsibility. The health department comes in on it so far as cesspools are concerned, but the district has to eliminate mosquito breeding hazards. The district can require the people to close them. In our district the matter is only referred to the health department when citizens refuse to cover their cesspools.

Mr. Gray: You have me somewhat on the spot. My policy may not be defensible legally, but we have an administrative problem on our hands. What would happen if we served notices, Bendel?

Mr. Bendel: I think we'd be found dead some night. We have about 600 cesspools in our division. The County Health Department will take no action. So we simply oil them as part of the routine. It isn't any particular hardship. If they did close them, the average citizen would only close them partially. I question whether many of them would close the cesspools sufficiently to prevent mosquito breeding. Unless a first-class mosquito-proof job is done, I would rather not have anything over a cesspool. It is easier to find and take care of it when they don't cover it up. The ones we have to dig down and excavate in order to locate are where we have trouble. I would much rather have them accessible.

A Member: I spent two years in Fresno where the cesspools were closed. If properly inspected they are no hazard.

Mr. Gray: In any case, we in our district have the proposition of whether we are going to stick our necks out and do the work of the health department. I think there is a principle involved in the thing.

Mr. Robinson: We have a few minutes for discussion before it is time to adjourn for dinner. Are there questions?

Mr. Bumiller: How toxic is DDT to water fleas, or Daphnia? We used 10 lbs. per acre and didn't get any kill on the Daphnia, but I'd like to hear something about that.

Mr. Gjullin: I saw an article to the effect that DDT was very toxic to Daphnia and finally will kill.

Mr. Bumiller: Under the law it really is the duty of the District to eliminate all mosquito nuisances, isn't it?

Mr. Gray: By the powers conferred under the California act the Districts may take all necessary or proper steps for the extermination of mosquitoes, and they may abate nuisances. If after due notice the nuisance is not abated, the District can abate the nuisance, possibly by proper reconstruction, and charge the cost to the property owner. In our district we have not taken that type of action. We haven't felt it necessary and believe it would not be advisable. We feel we get better results the other way.

Mr. Coburn: I don't happen to know much about mosquito breeding in cesspools. But I would like to know why different agencies come into a territory and make a survey, and don't let the adjacent districts know anything about it. Wouldn't it be advisable when they work in a district to notify the adjacent districts that they are coming? Possibly some of us might be of help to them in what they are trying to do. Some of us would be glad to help, and by this method learn something more ourselves. It seems to me it would be feasible and advisable.

Mr. Gray: Bring that up to Reeves. Would you be willing even to make a little trip to an adjacent county?

Mr. Coburn: Yes. We are only 38 miles from Bakersfield. When I found out about the Hooper Foundation work there, I was in Fresno, 150 miles from Bakersfield. Tulare, Visalia and ourselves (West Side District) would like to have seen the residual spraying demonstration.

Dr. Reeves: I think we could have used some men like Coburn and his equipment. Theequipment we had to use wasn't much good.

Mr. Gray: If the six hundred thousand dollars goes through we will probably have better information and supervision. Maybe those things can be ironed out.

Mr. Robinson: I suggest we send a wire to the Governor asking him to sign the bill.

Mr. Gray: I make a motion that the California Mosquito Control Association request the Governor by telegram to sign Assembly Bill 28 appropriating six hundred thousand dollars for mosquito control.

The motion was duly passed by unanimous vote.

The Conference then adjourned to re-convene at 8 p.m.

The Conference re-convened at 8 p.m., Professor W. B Herms presiding.

Prof. Herms: As our board of experts is fairly bubbling over with perspicacity, I will read each question which has been presented, and assign the questions to the men best qualified to answer them.

Question: Is DDT effective against termites? Dr. Stewart will please answer.

Dr. Stewart: I know very little about it. I am only drawing upon my memory but I have a vague idea which perhaps Dr. Freeborn can correct. Experimental work done upon termites to date has indicated that in certain sheltered conditions if impregnated in oil it is reasonably effective. Under buildings the soil saturation method is effective.

Mr. Murray: The Army had some experimental work done on the Florida coast. It worked O.K. in buildings. It was used in the barracks. There is a loose, sandy soil there.

Mr. Mondala: I want to mention the man of Mars outfit some folks think is necessary to wear when applying DDT. Did they wear it in Florida, for instance? In one lecture we are told to wear the whole protective equipment, and then in another lecture we are given the impression it is not necessary. And in the bulletin sent out, the Public Health Service shows a picture of a man in a Mars suit, and then another picture shows work being done with only the sprayer. One lecturer tells me all this protection is not necessary and another contends it is absolutely necessary. What am I going back to Washington with? What IS right?

I question the over caution on the use of DDT after the experience of those in Europe. They have been using great quantities. Some of them did wear something over the nose. DDT was applied by means of a duster by opening the clothing and introducing it is considerable quantities. Apparently there was no ill effects. One of the officers told me when there was objection he simply took some of it in the palm of his hand (he may only have gone through the motion of course) and swallowed it to show there was no danger. It has been used in great quantities without any ill effects at all. Dr. Stewart pointed out that so far as the use of dust is concerned there is no danger but with oil and other materials it is another matter.

Dr. Stewart: Even if you are dealing with a material far less toxic than DDT you still have to be careful. Under military conditions they were dealing with a controlled and disciplined group. If something went bad the public would not hear anything about it. But as civilians in government work , if you use DDT you are faced with the responsibility to take all due precautions. That I think is fundamental. You have the very real responsibility of protecting or at least not harming.

As regards DDT I am not going to guarantee that every person is going to die who uses it carelessly or that everyone who gets it on his skin in oil is going to be sick. However, it has been proved experimentally that in oil it is absorbed through the skin and may be absorbed to a toxic degree. If a person is just going out with a squirt gun and perhaps handle one or two rooms, it is ridiculous to take all the precautions, but if he is using a great deal he should protect himself while he sprays because there is a very definite element of danger.

The dust should not be allowed to remain upon the skin indefinitely. There is no record of deaths from DDT dust, but if a person has an oily skin and the dust is not washed off within a reasonable time it may have some bad effect.

We also should guard ourselves not just against DDT but against the solvents. Many of them are either toxic or can be at least very irritating to the skin. We must take precautions not only on our own account but we have also our employees to consider. Where we have employees handling it all the time we are responsible to see that they understand they are dealing with dangerous substances which may bring unwanted results if they do not take precautions which have been made clear to them. If you do not give protection and do what you can to see that the precautions are observed, then you are responsible if something happens. And if you do not state precautions to householders and they suffer some ill effects from DDT or its solvents and decide to take the matter into court, at the least you are going to be embarrassed or annoyed and possibly fined or held liable for damages. We know DDT is toxic. We know there are certain precautions which can and should be taken.

Prof. Herms: The next question is as follows:

Question: What is the time effect of DDT on flies?

I will assign this question to Dr. Stewart also.

Dr. Stewart: Our work so far has not brought out any particular difference in effect upon different species of flies, as there are several variable factors. If DDT is irregularly deposited in spraying, there may be an appreciable time factor before the fly in moving about on a sprayed surface makes a lethal contact. However, DDT is much slower in its toxic action than many of our common insecticides. My impression is that about three hours is the average killing time after a fly contacts a residual DDT surface. That is why pyrethrum is added to DDT space sprays, such as aerosols, to get a quick knock-down, while the DDT actually kills more slowly.

Walls, ceilings and door and window screens should be sprayed with DDT residual spray for fly control. And of course the garbage can attractsflies anywhere.

Mr. Mondala: I'm still not satisfied about all that equipment. Did Reeves' men take all those precautions?

Dr. Reeves: We read all the publications telling what should be done and then I laid in a supply of respirators, rubber gloves, etc., and explained to the men the danger. I insisted that so far as we were concerned they should wear these things. In Kern County in the middle of June the temperature is around 110 in the shade and you can well imagine nobody wore the things. They did, however, take the precaution of washing often. It is almost unbearable to wear rubber gloves with the thermometer at 110. Several of the men who had cuts did wear the gloves until the cuts healed. But workmen generally just don't want to wear them. I don't know what would happen if we made an issue of it. I guess the spraying just wouldn't get done. We had the equipment, made it available, explained its use, and why, and then left it up to them. Our men were only working a few days at a time. The program only lasted over a few days.

Mr. Gray: I think we will have to use common sense in this. If you use straight Diesel oil in a spray can, some of it is bound to get spilled on you once in a while. With knapsack sprayers it may be spilled down your back occasionally. In hot weather this may result in a blistered skin, caused by the Diesel oil.

You are not going to be able to get workmen to wear much protective equipment in the hot climates. You are going to have to take into consideration the type of exposure. If men are working outside spraying DDT more or less broadcast you should take the same precautions as when spraying paris green. The men should work from the windward side and clean up thoroughly afterwards. When they are working in confined places, such as underground street vaults, storm sewers or inside rooms, much more material may get on the skin, or be inhaled. I think it is necessary to protect your men reasonably well under such conditions. I don't think respirators are necessary. We are providing transparent hoods for our men. That prevents a man breathing any appreciable amount of the material unless he is using it in a very fine mist. Insist that every man you have working with the material takes a good bath with soap and water at the end of the day. We have provided shower baths with hot and cold water and the men are required to clean up. We do this partly for the sake of the district itself. We don't care about having a law suit on our hands. But it is also for the protection of our men. We don't want them injured in any way. We also have no desire to be charged heavy compensation insurance rates. I think if you talk to your men and explain to them the difficulties that may occur they will voluntarily take reasonable precautions. There is some danger there and we need to exercise reasonable precautions.

Dr. Stewart: I quite agree that respirators are only necessary in confined quarters. I think the men would be more willing to protect themselves if they use DDT in oil out of doors or in a large quantities if they understand the possible dangers. If we use it in large quantities and without these precautions which have been mentioned, next year or the following year we may hear at this conference a great deal of grief because of the material being absorbed through the skin. We cannot afford to ignore this matter. It has been carefully demonstrated by very competent people and we are taking a great risk if we do ignore these precautions. I would like to ask Dr. Bradley's ideas. He has had a great many men under him using DDT. How many have been affected? Have the men worn the equipment?

Dr. Bradley: We are teaching them and we are providing them with protective equipment, and telling them they should use it. We have then discharged our responsibility. If they, do not use it that is up to them. We can say "I told you so."

Although the men don't wear equipment to any great extent, we have not had any serious cases of injury. There has been a little dermatitis. What is going to happen next year I don't know. If we provide the equipment and tell the men to wear it that is about as far as we can go.

Dr. Freeborn: In some of the places they just couldn't work with power sprayers without protection. They couldn't stay in there without the equipment. They'll wear it when they know they have to. On the other hand, with a hand sprayer a man wouldn't get enough on his glasses to have to wipe them.

Mr. Stead: We can take a chapter from our experience in the public health field in industrial hygiene. I feel we have a closely parallel situation in the question of lead. That is a toxic material and so is DDT. We must make a distinction between what is toxic when introduced into the body and what is dangerous. Lead is absorbed through the skin, and can be inhaled or swallowed.

The particle size is important in relation to inhalation. If it is greater than about 10 microns the particle is too large to enter into the lungs and get into the blood stream. Welders may get lead poisoning, and rivetters on the Golden Gate Bridge had some trouble as a result of the effect of red hot rivets on red lead paint.

It has taken us a great many years to find out the conditions under which lead can be used with reasonable safety, but by making exact quantitive measurements we now know what protective measures are necessary against lead poisoning. We should also be able to get, perhaps within another year, fairly good information on the toxicity of DDT, though tests under practical working conditions may well take more time. But many people are safely using lead, a poisonous material, today, and we will also learn how to use DDT safely.

One point should be emphasised and that is that the solvents for DDT are themselves toxic. Tetrachloroethane, carbon tetrachloride and other solvents are poisonous, and we need to learn to use them safely, also.

Prof. Herms: It should be remembered that in agriculture and in pest control work we have used poisonous materials for many years. Thousands of tons of cyanide are used, and even more tons of arsenical compounds. Years of experience have taught us how to use these very toxic materials safely. We can also learn to use DDT safely.

Question: What would be the radius of control and the flight range of the following mosquitoes: Anopheles freeborni, Culex tarsalis?

Dr. Freeborn: The flight range of a mosquito is a random flight. I don't think you can say a mosquito starts out with a fixed idea he is going four miles. He starts out and flies perhaps half a mile. The next night he may go in the same direction or he may double back. At the end of several days he may end up where he started from. Or maybe he will be four miles from the starting point. If you want a practical answer so far as control is concerned, you will get perfect control if you kill all of them within a mile or a mile and a half from the place you are trying to protect. However, this statement has no application to the spring and autumn dispersals of Anopheles freeborni. They start out in the spring of the year with plenty of water. Later the amount begins to decrease and so they concentrate. In the fall their breeding is over and they realize they are concentrated, and along about September or October or even earlier they start flying again without any limitation as to how far they will fly, perhaps as much as 27 miles.

Question: Does the wind make much difference?

Dr. Freeborn: Not with Anopheles. Some feel that they follow the wind. Rush used to say the north wind created a vacuum.

Prof. Herms: Again you say adequate or practical control. That is a very important angle for all of us.

Dr. Reeves: We don't know about the flight range of Culex tarsalis. We haven't been in a situation where we could trace them in our study, and so far nobody has made experiments with stained specimens. I wouldn't want to set any limits.

Dr. Freeborn: You can always find some tarsalis breeding within a very short distance of where you find the adults.

Mr. Gray: The flight range of Aedes dorsalis ranges in the region of 20 or 25 miles. If you really want a long distance traveler, Aedes squamiger flies over 40 miles and some think in the region of 60. My own impression is that the flight range is about 20 to 25 miles for dorsalis and up to 40 for squamiger. Aedes squamiger would take about three weeks for a 40 mile flight.

Mr. Menefee: Does that apply to the salt marsh variety?

Mr. Gray: Yes.

Mr. Robinson: My experience would be that fresh water dorsalis and nigromaculus can be fairly well controlled for they will stay practically within the field from which they breed. If they over produce in that field they will move off. Search for food makes them move. A three or four mile flight would be natural for dorsalis in the valley and generally elsewhere. For vexans it would be a little more.

Prof. Herms: The flight range varies greatly according to species. The time of year and also local conditions play an important part.

Mr. Gray: Generally speaking, most of our domestic mosquitoes travel something like a few hundred yards from where they breed if the food supply is there. All of them most likely travel as far as necessary in order to get food.

Mr. Peters: A very ticklish situation developed in the Sacramento area. It is all well and good to say 1 mile or 1½ miles for 3/4 of the year. But what about the other 1/4 of the year? Supposing you were the man in Sacramento -- what would you say then?

Dr. Freeborn: There is no point in trying to control mosquitoes when you are not breeding them. Consider the Sacramento Valley area. Breeding occurs all up and down the valley, yet some areas need no control work at all. There can be good control in Sacramento from March 10 to August 30th, but for September and October and the big flight in February, there would be no guarantee at all.

Prof. Herms: What can you assure them with reference to malaria?

Mr. Raley: I have had some experience in a freeborni district. We increased our control roughly 2½ miles in the control area. We still found that during the winter months we were badly bothered with freeborni, so in setting up our district we went as far as legal and natural boundaries would allow. We went to the county line in both counties. Apparently these mosquitoes travel many miles.

Dr. Freeborn: Anopheles freeborni when it migrates is a random migrator. About 1% probably succeed in straightening out their travel and going half a mile in a night. In 4 nights they will have gone 2 miles on this basis. But probably only about 1% will do this. Some of them are going to get into the district. If you have 1,000 10 will get into the district. The more you have of breeding concentration on the edge of the district, the more are going to get in until they get to where they are a real pest. A big concentration on the boundary means they go further. The bigger concentration on the boundary you have, the greater the number that will go further than a mile will be. Then you will have to go further than a mile to control them.

Prof. Herms: If the new law is passed, it will be possible to go further in control work.

Question: Will the control of Mosquito breeding in the larval stages eliminate adult mosquitoes in a local area within two weeks under average conditions?

Prof. Herms: This question pertains to the length of life of the mosquito. Dr. Freeborn, supposing you take the question.

Dr. Freeborn: A great deal depends on climatic conditions. High temperatures and low humidity mean a short life span for the mosquito. They won't live too many days. But some species can live all winter, and the snow mosquitoes about a month. We used to say we would give ourselves a month for control results.

Mr. Robinson: About ten or twelve years ago one superintendent said he always told people that it would take two weeks before the work of the district would become really effective and he has never failed yet. He knew that when they had a flight of mosquitoes it would last just about two weeks.

Prof. Herms: Occasionally it was necessary for me to go out into the state and when some lady would see me she would tell me how glad they were I was back because the mosquitoes had been just terrible while I was away but that now they had completely gone. The flight was over. I hadn't done a thing about it. This business of guaranteeing a certain length of time in which the trouble will be cleared up can be dangerous. Under certain conditions you may expect a considerable reduction in a certain time but you can't just generalize.

Mr. Gray: My very excellent secretary receives every year a number of complaints of local breeding. She tells them when they call that someone will be out to take care of the situation for them and thanks them for letting us know. She also tells them to kindly let us know if they are still troubled after a few days; to phone us again if there is not a decided improvement by say next Wednesday or Thursday. We figure that in about four days after the men have been out there should be a definite improvement and, in some cases, no more mosquitoes at all. If there is no improvement in that length of time, we figure that though we may have found a place where the mosquitoes were breeding or even several places, there is some other place not yet located.

Mr. Robinson: In our experience down in the valley we do the same thing Mr. Gray does. We tell them that if the mosquitoes are still bad the next week to be sure and let us know. As a rule, there is a difference in three or four days and then they disappear altogether.

Question: What about food for fish (Gambusia)?

Mr. Gray: If there is no natural vegetation in the water, plants should be obtained and planted in the breeding pond. It is well to plant some green algae also in the pond. If it is an artificial pond, it is usually necessary to feed the fish at first until algae and vegetation become established. Dog biscuit broken into small pieces is good. We have used Friskies. Fish will also eat stale bread, but this is deficient in protein. There are several large ponds at Mission San Jose which we have the privilege of using for Gambusia breeding. In the summer we have to clean out the excessive growths of algae and aquatic vegetation. If you have a natural growth such as we have there, you do not need to feed the fish at all. If you have large concrete basins or tanks, simply plant some aquatic plants and within a comparatively short space of time there will be enough natural algae so that no other feeding will be necessary.

Prof. Herms: I have found it unnecessary to feed the fish. If once established, year in and year out they will maintain a population adjusted to the available natural food supply.

Question: How long will DDT be effective on the inside walls of concrete irrigation pipes?

Mr. Robinson: I haven't used it in pipe lines.

Mr. Gray: We have good results for at least three months on concrete vaults, but we don't have the fluctuations in water levels which occur in risers on concrete pipe lines.

Question: Are light traps of any value in a well-organized program? If so, what is the value?

Dr. Bradley: They are extremely valuable to give an index and for comparison from season to season. They are, of course, much more indicative in some places than in others. In one locality we had quite a few out to measure the density of quadrimaculatus.

We only got one or two or maybe three quads per night. Our small catch didn't mean they were not there, but only that they were not coming to the traps. For pest mosquitoes, light traps are often of great value in obtaining an index and in making comparisons.

Prof. Herms: The light reaction varies to the species. We know very little about these reactions but we know there is a great difference between species and light traps do serve as an index.

Question: Which is best to organize for control -- A Pest Control or A Mosquito Abatement District?

Mr. Gray: I would say that a Mosquito Abatement District is best from the standpoint that you are free from any interference by the Board of Supervisors in regard to the amount of money you levy provided you stay within the limit set by law -- 15¢ normally, but it may be as much as 40¢ with the permission of the Board of Supervisors. The pest abatement law states that the supervisors shall levy a tax sufficient to raise the amount of money necessary for control. The mosquito abatement act says that the Board of Supervisors shall levy a tax sufficient to raise the amount of money certified by the Board of Trustees of the District. This is an appreciable difference if one has a hostile Board of Supervisors. Aside from this difference, I would say that the mosquito abatement act is more specific in its field, but in practice there is not too much actual difference.

The mosquito abatement law is to be found in Sections 2200 to 2398 of the Health and Safety Code. The law governing pest abatement districts is in Sections 2800 to 2922.

Mosquito abatement districts are governed by a board of trustees. The city council of each city included in the district appoints a member. The board of supervisors appoints at least one member to represent the county at large. A board of trustees must consist of at least five members. It is the responsibility of this board of trustees to determine the policy of the district, employ the personnel, prepare the budget and control the finances. Pest abatement districts have practically the same powers as mosquito abatement districts but are at a disadvantage financially if they happen to have an unfriendly board of supervisors. The board of supervisors can, if they so desire, cut the appropriation for a pest control district to practically nothing.

Question: Under the new law, what is the best procedure to follow in setting up a new county wide district? How long will it take before a district can be organized and set in operation?

Mr. Gray: If the Board of Supervisors will initiate proceedings by a resolution, publication and hearing, it should not take more than approximately a month to organize a new district now that the District Investigations Act is eliminated. If proceedings are initiated by a petition of the electorate, I doubt that a district can be organized under about two months' time, even with no opposition. You will find it is going to take quite a little time to persuade people that a district is necessary and should be formed. You won't get these things over unless you have prepared the minds of the people. In some cases you will find it has taken several years of education to get to where you can organize.

A Member: I know one district where it took seventeen years.

Question: Does DDT have an accumulative poisoning effect on live stock?

Dr. Stewart: In oil, it is absorbed through the skin and apparently is accumulative. It is secreted in the milk of animals. It is very difficult to interpret the information now available. Perhaps DDT is similar to lead in its poisonous effects. Lead is stored up without apparent harm until it reaches a toxic level. Whether the storage of DDT is comparable is not yet known. Those most concerned with this problem are connected with the department of agriculture, and they are urging caution and yet greater caution.

Mr. Gorgas: There has been some work done on that by Neil. He definitely claims there is an accumulation.

Question: How long will DDT be effective on vegetation along irrigation canals?

Mr. Robinson: It is difficult to determine the lasting effect, if any. Possibly the use of DDT enabledus to go three days longer than with straight diesel oil. In clover fields which are irrigated every 8 to 12 days we found that with DDT we could skip every other spraying.

The meeting then adjourned.

The meeting re-convened at 9:15 a.m., Tuesday, February 26, 1946, President Robinson presiding.

Mr. Robinson: The first paper today is concerned with the special training course conducted at the University of California in December, 1944. It will be presented by Harold Gray.

THE SPECIAL TRAINING COURSE ON CONTROL OF
MOSQUITOES AND MOSQUITO-TRANSMITTED DISEASES
GIVEN AT THE UNIVERSITY OF CALIFORNIA
DECEMBER, 1944

By

Harold F. Gray, Lecturer in Public Health
School of Public Health
University of California

During the period December 4-16, 1944 the School of Public Health at the University of California, in cooperation with the Division of Entomology and Parasitology, College of Agriculture, conducted an intensive short course of instruction on the control of mosquitoes and mosquito-transmitted diseases. Twenty-four men, coming from mosquito abatement districts and from various health departments, attended the course. Twenty-two were from California, with one each from Washington and Utah. Fifteen were employed by mosquito abatement districts, eight by state health departments, and one by a city health department. Twenty-two received certificates of satisfactory attendance while two failed.

The teaching staff was obtained from the University faculty, the State Department of Public Health, the Hooper Foundation for Medical Research,and various other agencies.

Instruction was grouped under four main headings:
(1) Administration and Management, 18 hours; (2) Entomology and Parasitology, 25 hours, nine of which were in the laboratory; (3) Mosquito-transmitted Diseases, 6 hours; (4) Techniques of Control, 46 hours. In addition to the laboratory work, the instruction consisted of lectures, demonstrations, seminars and motion pictures.

Our experience with this course indicated that it was too intensive and too short for the best results, and we are of the opinion that if such a course should be given again it should be either expanded to at least a four weeks' course, with ample time for directed reading and study, plus several days of field demonstrations, or if it is impracticable for some of the districts and health departments to carry the cost of a month's salary and expenses of an employee, then possibly a course could be worked out wherein directed study could be carried on by extension during a preliminary two months period, followed by two weeks intramural training at the University.

At the present time, many in the University faculties are so "fed up" with the numerous short, intensive, specialized courses required primarily for military purposes during the war, or for emergency civilian purposes, that it seems improbable that any more short courses will be considered favorably, even though an appreciable demandfor certain types of short courses may continue.

However, there is little question but that there is a need for some form of special training for mosquito control workers, and possibly this Association might do well to set-up a committee to study the matter and report their findings and recommendations after conferences with educational authorities and official agencies. It might also be advisable to consider the matter of some type of state regulation of mosquito control personnel, with qualifications and examinations, possibly along the line recently taken by the Legislature in certifying sanitarians in health departments.

Possibly it is time that we appraised the education and technical training essential to the successful conduct of mosquito control work, and then explored the means by which such training, at least, may be made available to those who require it.

In New Jersey a course was given from February 24 to April 28, 1945, each Saturday afternoon. The total time consisted of 27 hours, as contrasted with the 95 hours total time in the California course.

Mr. Robinson: The next paper is by myself.

MOSQUITO LEGISLATION

By

E. Chester Robinson
Superintendent,
East Side Mosquito Abatement District

The California Legislature at the 56th First Extraordinary Session has just passed the following bills, A. B. 27, A. B. 28 and S. B. 61.

A. B. 27 has been signed by the Governor and contains the following provisions: "No district formed or proposed to be formed under this chapter shall be subject to any of the provisions of the District Investigation Act of 1933. This section shall remain in effect until the ninety-first day after final adjournment of the Fifty-seventh Regular Session of the Legislature and thereafter shall be of no force or effect. This act is hereby declared to be an urgency measure necessary for the immediate preservation of public peace, health or safety within the meaning of Section 1 of Article 4 of the

Constitution and shall therefore go into immediate effect. A statement of the facts constituting such necessity is as follows: There have entered and are continuing to enter the State many persons who have been infected with and are carriers of mosquito-borne diseases. Unless immediate and effective measures are taken for the control and suppression of mosquitoes serious epidemics of mosquito-borne diseases will occur. The organization of additional mosquito abatement districts to take such measures is urgent, but the procedures now required under the District Investigation Act of 1933 are both costly and time-consuming. For the immediate protection of the public health it is necessary that this act, making the District Investigation Act of 1933 inapplicable to mosquito abatement districts, take effect immediately."

A. B. 28 contains the following provisions: "The Department of Public Health shall make the necessary studies and demonstrations to determine the areas of the State which have a high proportion of mosquito borne diseases, including but not limited to malaria and encephalitis. The department is hereby authorized to enter into cooperative agreements with any local district or other public agency engaged in the work of controlling mosquitoes in such areas under terms, conditions and specifications as the State Board of Public Health may prescribe. Such agreements may provide for financial assistance on behalf of the State and for the doing of all or any portion of the necessary work by either of the contracting parties, except that in no event shall the department agree that the State's cooperation shall exceed 50 per cent of the total cost of any acceptable plan. Sec. 2. The sum of six hundred thousand dollars ($600,000) is hereby appropriated out of any money in the State treasury not otherwise appropriated to the Department of Public Health, to be used for the purposes of this act during the Ninety-seventh and Ninety-eight Fiscal Years. Not more than two hundred thousand dollars ($200,000) of the amount appropriated by this act shall be used by the Department of Public Health for making the necessary studies and demonstrations and administering this act. Sec. 3. This act is hereby declared to be an urgency measure necessary for the immediate preservation of the public peace, health, or safety within the meaning of Section 1 of Article 4 of the Constitution and shall therefore go into immediate effect. A statement of the facts constituting such necessity is as in A. B. 27.

I was just in touch with the Governor's office by phone and although we anticipate that the Governor will sign the bill as passed, he has not and will not sign any bill containing appropriations until they are all in and he ascertains the amount of money available and which bills will have to receive a cut in appropriations. It is possible that by the end of this Conference we may have this information.

S. B. 61 is all filed ready for the governor's signature and also carries an emergency clause which makes it effective immediately upon the governor's signature and as there is no objections or controversy on this bill, I believe that we are safe in assuming that the Governor will sign this bill in the next few days. S. B. 61 provides that Mosquito Abatement Districts may raise their tax limitation above 15¢ per hundred on the assessed valuation with the approval of the Board of Supervisors of the county or counties in which the district operates, the maximum being 40%.

Special mention should be given to Dr. Halverson, Director of Public Health, who so favorably presented the arguements in favor of A. B. 27 and 28. Special mention should also be given to Ed Reinke, State Bureau of Sanitary Engineering, Arthur Geib, Superintendent of Dr. Morris Mosquito Abatement District and to the late Bob Pirie of Fresno Mosquito Abatement District, who were on hand if it had been necessary to present additional facts to the Assembly Ways and Means Committee. I wish to thank Superintendent and members of their boards for the work they did in contacting their senators and assemblymen. This preliminary work, I firmly believe, made it possible for the easy sailing we had in the various committee hearings. I would suggest that Superintendents and board members write their senators and assemblymen thanking them for the assistance they gave in passing these bills.

Mr. Robinson: It will be a matter of interest to you to hear that the legislature has appointed a committee to overhaul completely the Districts Investigation Act and report its recommendations to the 1948 session.

I will now ask Dr. W. C. Reeves of the Hooper Foundation for Medical Research to preside.

Dr. Reeves: Up to this moment I have been thoroughly enjoying this meeting. I am glad, however, that I do not have to give an extemporaneous talk.

Dr. Halverson, the State Director of Public Health, was to have presented a paper on the outlook for mosquito-borne disease control in California. By agreement, however, this paper will be presented by Frank Stead.

THE OUTLOOK FOR MOSQUITO-BORNE DISEASE CONTROL IN CALIFORNIA

By
Frank M. Stead, B. S., M. S.
Chief, Div. of Environmental Sanitation
Calif. State Dept. of Public Health

There are two mosquito-borne diseases that occupy a place of importance in California today; they are, of course, Malaria and Virus Encephalitis. From a public health point of view we are interested in the field of mosquito control in this State only insofar as it relates to these two diseases or to other mosquito-borne diseases that may appear in the future. It is important that we keep this point always in mind because it is the criterion on which the whole matter of cooperation between public health agencies and mosquito control districts hinges.

Before we can successfully control a mosquito-borne disease, we must be in possession of basic information enabling us to answer four questions: -

(1) How is the disease transmitted to men?

(2) How is the disease kept alive in endemic areas?

(3) What are the principal vectors?

(4) Where are the endemic areas?

Let us briefly review the present state of our knowledge of the two diseases in question with respect to these four questions.

First, how is the disease transmitted to man? Malaria is transmitted from man to mosquito to man with no known exceptions. There is, therefore, only a single, straight chain to be cut and it may be cut at any of several points. Virus Encephalitis, on the other hand, is thought to be transmitted primarily from bird to mosquito to bird with man (and horse, in the case of Western Equine type) being infected by the bite of a mosquito which has become infected by biting a bird.

The second question was: how is the disease kept alive in endemic areas? In Malaria the only reservoir of infection is man so both infected men and the vector mosquito are needed to keep the "endemic fire" alive. For Virus Encephalitis, on the other hand, the presence of infected men has no relation to the endemic persistence of the disease in an area (if our present information is correct). What is needed is an infected bird population and the vector mosquito. Other environmental factors such as mean temperature are, of course, of importance for both diseases.

The question as to the principal vectors for each disease can be answered with considerable assurance in the case of Malaria but only provisionally for Virus Encephalitis. Anopheles freeborni has been shown to be the chief Malaria carrier in this State. Studies by the Hooper Foundation in Kern County show that Culex tarsalis has by far the highest infection rate for Virus Encephalitis of all the mosquitoes tested. Several other species, however, including Aedes dorsalis, Culiseta inornata, and Anopheles freeborni have also been found infected and it would be unwise at this time to overlook the possibilities of these other species.

The last question was: where are the endemic areas? Studies by Professor Herms and records of the State Department of Public Health clearly show that in the years preceding 1920 Malaria was generally prevalent throughout the great central valley of California, extending from Shasta County on the north to Kern County on the south. In the five years following 1920, as a result of mosquito control and other factors, the incidence of Malaria as measured by reported human cases dropped steadily downward from a high of over 1000 cases in 1919 to less than 100 in 1925. The reported human case incidence has remained at about the 1925 level since that time with the exception of an upward resurgence with subsequent fading between the years of 1935 and 1940. The geographical distribution of these cases is impossible to define with exactness since our records show where the cases live and this may not be where they acquired the infection. In general, however, the northern half of the central valley may be considered as our best estimate of the present Malaria endemic area. It is apparent to all that the return of infected veterans in considerable numbers to areas inhabited by the vector mosquitoes may change this picture.

It is an extremely questionable practice to attempt to define the Encephalitis endemic areas on the basis of reported human cases for several reasons. Diagnosis of the disease is probably missed 50% of the time and as in Malaria the place where infection is acquired is very often not the home. What is more significant is the fact that humans are not the reservoir of infection. Incidence of horse cases of Encephalitis would be a much more reliable guide since horses travel less than men, but here again we are stopped because the reporting of horse cases has not been carried out in any systematic manner. If, however, as seems the case, we are forced for the present to make our estimate of location of endemic areas of Encephalitis on the basis of reported human cases, we find that for the three years - 1943 to 1945, inclusive - the total reported cases in the fifteen counties of highest total incidence are as shown in the following table:

<u>Human Encephalitis - 1943 to 1945, Incl.</u>

Order	County	Human Cases
(1)	Kern	140
(2)	Fresno	94
(3)	Tulare	55
(4)	Yolo	28
(5)	Sacramento	27
(6)	San Joaquin	27
(7)	Kings	23
(8)	Alameda	23
(9)	Los Angeles	14
(10)	Stanislaus	12
(11)	Madera	9
(12)	Yuba	8
(13)	Solano	8
(14)	Sutter	7
(15)	Contra Costa	7

If we examine these figures in light of population in the several counties in question we see that there are two <u>apparent</u> foci of Encephalitis in California today, one area in parts of Kern, Tulare, Fresno and Kings Counties and one in San Joaquin, Sacramento, and parts of Yolo and Sutter Counties. It should be re-emphasized that these areas are nothing more than our best guess at the present time. It should also be noted, however, that the northerly of these two areas is <u>jointly</u> a Malaria and Encephalitis area.

It becomes apparent from this brief discussion that whereas we probably have enough knowledge of these two diseases to make a start on control this year, that control cannot be complete and in fact may be so much a "blind" attack as to be of little value unless we at once fill in the many gaps in our fundamental knowledge relating to these two diseases in California. It is almost axiomatic, therefore, that any program for the control of these diseases must be two-fold: fact finding and direct field control work.

We pass now from a consideration of basic principles to their application in the program immediately impending in this State if the appropriation bill (A.B28) recently passed by the Assembly and Senate receives the Governor's signature and becomes a law.

The responsibility for carrying out that program rests with the State Department of Public Health but the actual control work in the field must be done by local agencies such as Mosquito Abatement Districts and County Health Departments. Plans for this program have been built up as a result of a series of conferences with representatives of agencies having an interest in this problem. Briefly stated, the program is in two parts, as follows:

(I) Fundamental studies leading to a better knowledge of the diseases in question and the location of their endemic areas in the State.

(II) Direct control in the field by local agencies, of the important mosquito vectors; this control to be partly financed by subventions allocated by the State Department of Public Health.

The scientific studies will be of five separate types.

(a) Basic biological research. This activity will be carried out in a test area under the auspices of the Hooper Foundation and will follow up the work done by that agency in Kern County in 1945.

(b) A State-wide mosquito survey. This project, which to be of value must extend over several years, is for the purpose of determining the density of important species of mosquito vectors and their infected rate in different parts of the state.

(c) A State-wide blood sera survey. This project, which will refer only to Encephalitis, is for the purpose of locating the infected bird reservoirs and determining animal infection rates. Coupled with the results of the mosquito survey, it should enable us to define the areas where the greatest problems exist.

(d) A complete investigation of all known human and animal cases of Encephalitis.

(e) A demonstration and study project in an area endemic to both Malaria and Encephalitis. This project will include studies of the habits of the vector mosquitoes and the effects of various methods of control.

It will be the experimental area for the trial and development of mosquito control methods which will be used by the local agencies in their work under subvention agreement.

The direct control work by local agencies must, of course, be subject to certain terms and agreements. It is planned to develop such specifications and terms with the aid of an advisory committee representing mosquito districts, local health departments and scientific agencies. This work has not yet been done and it is impossible to present the details at this time. The requirements and specifications will, however, be based on the considerations presented in the first part of this discussion and will be of the following nature:

(a) Before a subvention can be granted it must first be established that the area to be controlled is an area of Malaria or Encephalitis threat.

(b) The agency applying must agree to match all funds received on subvention and spend the entire amount in the area defined in the agreement.

(c) The applying agency must agree to perform the disease control work in conformity with methods to be outlined by the State Department of Public Health.

(d) The applying agency must employ personnel trained and skilled in the field of mosquito control.

So little time remains before the start of the 1946 mosquito season that we know it will not be possible to cover all the endemic areas of the State this year with intensive control programs. Many such areas will not be defined until the fact finding studies are well under way. In some already known areas no mosquito abatement districts exist, and it may not be possible at once to develop a control program through the local health department. It is hoped, however, that both the districts and the local health departments will enter whole-heartedly and understandingly into this cooperative program and thereby demonstrate that independent local agencies can voluntarily join forces under the leadership of a State department to successfully attack a common problem.

For our part, we will undertake to minimize the red tape and delay which so often are associated with so large a project and at the earliest possible moment after the signing of the bill, place in the hands of every mosquito abatement district and county health department the rules and specifications pertaining to subventions. May we assure you that in drawing up these rules and specifications we will lean heavily on the advice of the advisory group with adequate representation from the districts themselves, and that this group will assist us in reviewing the applications for subvention funds.

Dr. Reeves: Before discussing Mr. Stead's paper, I will present my own, and then the two papers can be discussed.

SUGGESTIONS REGARDING CULEX TARSALIS CONTROL IN ENCEPHALITIS AREAS

By
William C. Reeves, Ph.D.,
Hooper Foundation for Medical Research
University of California

The programs of most mosquito abatement districts in this State have to a great extent been directed against Aedes and Anopheles mosquitoes. This is an essential program and must continue to receive a major proportion of your attention. However, during the past five years, it has become apparent that a mosquito, Culex tarsalis, which had heretofore been considered a pest mosquito, of relatively minor importance, must now be looked upon as a species deserving major consideration. It is now known to be an important vector of a group of diseases of man and horse, known as the encephalitides - or more commonly sleeping sickness or brain fever. In Kern County, California, Culex tarsalis has been found infected 58 times with Western equine type encephalitis virus and in addition, several isolations of St. Louis virus have been made from this species. Investigations in several other Western States have given similar results. In parallel studies, no other species has been found infected more than twice. It appears that C. tarsalis is the important vector of these two types of encephalitis and each summer the disease is recognized over a large part of the State, with the highest incidence in the San Joaquin and Sacramento Valleys. At past meetings of the California Mosquito Control Association, there have been many discussions, and even arguments over the importance of this species, and whether it bites man. We can now say that it is definitely an important mosquito as a disease vector, and that it frequently feeds on man.

Culex tarsalis is undoubtedly the most widely distributed mosquito in the State, and is exceedingly common over most of its range. The problem of controlling this species is a difficult one as its larvae are probably found in a wider variety of breeding places than any other species in the State. Larvae may be found in all types of water, fresh, stagnant, polluted, alkaline, or acid, and in large bodies of water or in the smallest collection - such as in hoof prints or water containers.

Mosquito control operators from several sections of the State have attempted to increase the scope of their control measures to include this species and they have found that its control is not easily accomplished. I have received numerous requests for assistance in this problem and it has frequently been possible to assist in locating breeding areas. The answer to this problem is the organization of a carefully carried out inspection service. To function effectively, inspectors must have or develop a knowledge of the ecology of the adult as well as larval mosquitoes. Inspections should not be limited to a search for larval breeding, but should also include a survey of adult resting places. It is frequently possible to approximate the location of larval breeding areas by observing differences in adult populations in various shelters in a region.

I believe that a flashlight and adult collecting tube are as essential a part of your equipment as the dipper which most of you carry. One complements the other and both are needed for an effective evaluation of the Culex problem. Because of the difficulties encountered in locating Culex breeding places, your first indication that breeding is going on may be the finding of adults. Probably the one type of shelter which will offer the best checking station is the chicken house. Culex tarsalis, C. 5-fasciatus, and C. pipiens are strongly attracted to these shelters because of their affinity for bird blood. In the past three years numerous collections have been made in the Bakersfield and Fresno districts and while Aedes and Anopheles control was quite effective, it was still possible to collect hundreds of Culex mosquitoes in chicken houses and other shelters. The breeding areas from which these mosquitoes were coming could oftentimes only be found by an intensive search and occasionally they were so well hidden that they could not be found at all.

Methods of species sanitation for the control of C. tarsalis have not yet been developed and until a more complete biological study has been made and possibly new, more effective control measures developed, this problem will have to be attacked with all the available tools now used for general control. The treatment or elimination of larval breeding areas should be carried out on a large scale. It will be found that a majority of these breeding places are man made. Inefficient handling of waste irrigation waters, badly managed water storage reservoirs, and the innumerable water containers about domestic habitats must be controlled as well as naturally occurring breeding places along waterways and in flooded areas. Very often this type of water is treated because of the Aedes problem, but not checked again after the Aedes brood has disappeared. Culex breeding occurs many times in the residual water several weeks ater the Aedes have disappeared and should be checked.

As was indicated in yesterday's discussion, the use of DDT residual deposits in the adult resting shelters will assist in the control of Culex. However, this is not the answer to complete control, as large numbers of specimens remain in the wild and do not enter these shelters. DDT treatment of domestic shelters will undoubtedly reduce the hazard of exposure to encephalitis infected mosquitoes, but will not eradicate the disease.

Dr. Reeves: We now have time for considerable discussion of these two papers.

Question: Who will be responsible for spending the State money allocated to the districts?

Mr. Stead: The district, through its Board, will present an application to do a certain program in a certain area. It will substantiate its program in a mosquito-borne disease area. In encephalitis, for instance, it will work up evidence which it is able to obtain. The department will reinforce this report. The money will only be granted when the case is made reasonably clear that the funds are going to be spent for disease prevention.

One suggestion is that we have some formula for appropriation of funds, relating to the size of your present program, but we feel that would hamper us in the situation. It is not our thought to set a ceiling. An amount may be applied for which is five times what is needed. When an application comes up for decision, the facts will be weighed and money given accordingly. If it is considered a good project, an equitable grant of money will be made. It will be your program once the funds are granted. You will employ the personnel and do the work. It will be subject to the supervision of a trained man from the State Department of Public Health who will work with you and keep you thoroughly informed from their experience.

An advisory committee will be set up to help in planning and on the allocation of funds. There will probably be three representatives from this Association, as well as representatives of local health departments and other interested groups.

Mr. Gray: What about the new districts now being formed? Do you think there will be an appreciable difficulty because they are late in getting started?

Mr. Stead: I don't believe it will make much difference. The district has to put in half the money. Think of this as a progressive thing. The program will demonstrate its workability and its practicability. You have this season and then you have the first few months of the 1947 season on this one appropriation, so if the results support the spending of money this year it is very possible it may be right for subsequent years. We have to look further ahead than just one season.

Mr. Raley: How can a newly organized district obtain cash money with which to operate until the first collection and apportionment of taxes.

Mr. Gray: We had that problem in Alameda County.

The first year (1930) we operated we were organized too late late (after the first Monday in March) to be able to levy taxes for the ensuing fiscal year. Arrangement was made with our Board of Supervisors for a county appropriation of $25,000, and our employees were carried as employees of the county under civil service until June 30, 1931. At that time our own tax went into effect and then we were able to draw against our own tax funds. The Board of Supervisors then loaned us money to carry us during the first five months of the 1931-32 fiscal year until taxes came in, and then we repaid the loan.

Mr. Raley: The point I was trying to bring out is are we to spend money on a matching basis program with the State, and this requires that actual work be done, so we must raise our share of the cash.

Mr. Stead: There are several alternative solutions to this problem, one of which would be to work through the county health department during the first year until the mosquito abatement districts' own funds are available. Their interent overlaps with yours in mosquito control. They can apply for money from the Board of Supervisors.

Mr. Russell: Hanford started last year in April. The State Attorney ruled money could not be borrowed but we could enter into a contract to do work. The Chamber of Commerce did that for us, and, were repaid in the next fiscal year. All bills were charged to the Chamber of Commerce. We are going to have to carry that method on, doing three years work on two years budget.

Mr. Stead: Regardless of how it is done, the application must guarantee that the money is forthcoming. It must be legal.

Mr. Bumiller: (Los Angeles) I don't believe any district would have trouble if they would cooperate with their local health officer, especially if the state finds there is a mosquito-borne disease problem. I know our county council would allow any reasonable amount to be set. We got a loan.

Mr. Stead: San Joaquin County is an important area from this standpoint. It has one of the best local health departments. We would be closing our eyes if we didn't expect the health district there to take an important part and join forces with the mosquito abatement district. There is a stronger program if there is cooperation between the health department and the mosquito abatement district because you have more people interested, and in succeeding years they will work up evidence to substantiate the work that needs to be done. If they can get their local veterinarians to report horse cases and get the doctors to report all encephalitis cases, it will mean a lot. The county that does that is in the best position.

Prof. Herms: Since the endemicity of the two disease complexes are the affairs of this program, it might be well for you to understand that it is a relatively simple thing to determine the endemicity of malaria. It is not so simple to determine the endemicity of encephalitis. I would like to suggest that the horse disease is an index (not a complete index, of course) but we are sometimes inclined to overlook that particular feature. Your veterinarians in your area may or may not know much about the prevalence of equine disease, but whatever knowledge is to be found among them will be exceedingly helpful. If you have a good deal of equine encephalitis, it is a pretty good indication that you are in an area of some importance. The equine encephalitis angle through the veterinarians must not be over looked.

I was wondering whether we are not approaching a period here in California which resembles in many respects the Aedes aegypti program in the south where most careful inspection and training of workers to gather information regarding this particular species was necessary. What about the inspectional angle? Will we need to do this now?

Dr. Freeborn: The Culex tarsalis problem is just a whole lot tougher than the Aedes aegypti problem, which is limited to individual containers and is almost 100% associated with human habitations. You are going to have to do all you did in the Aedes aegypti control program and then go into the rural areas and do much more there. Tarsalis is about the last species that would ever come under a program of species sanitation which means the control of one particular habitat.

Any breeding place in which you find any mosquitoes at all you may find tarsalis.

Col. Bradley: In the MCWA program we found inspectional service to be of tremendous importance. We have been able to reduce the amount of actual control work by careful inspectional work. Even though you have to take care of a wider variety of places than in species sanitation, still you have to know the different places where they are or are not breeding.

Dr. Reeves: On account of time limitations, we must now pass on to the next subject. We were unable to get a speaker from the State Employees' Retirement System, so of necessity we must call upon our old stand-by, Harold Gray, to discuss the subject of pensions.

Mr. Gray: For quite a long while employees of the mosquito abatement districts and some other special districts were the only people who did not have some form of retirement act provision for those who had served for an appreciable number of years. They were not eligible for the federal social security benefits. They could not be taken into any county pension plan. And under the form of the act covering the state employees, they were not eligible for that either. About 1940, we of the Alameda County Mosquito Abatement District started to explore what could be done to bring our employees into some pension scheme and we found that we could not without extreme difficulty get the Alameda County retirement system changed by a charter amendment to bring us into the county system. We then began exploring the possibility of amending the state act to permit our district to come in.

We finally succeeded in having introduced into the Legislature of 1942 an amendment by which all special districts could come into the State Employees' Retirement System on the same basis as cities and various other agencies, under the general name of a public agency. The Alameda County Mosquito Abatement District worked out in connection with the System a bill which was approved by the Legislature and signed by the Governor. We expected it to go into effect about August of 1943, and we and a number of other districts undertook the preliminary steps for bringing our employees into the System so they could receive the benefits. The first step consisted of making a request to the System for an actuarial survey of the employees of the district in order to determine the cost to the district of bringing these employees into the System. We have been in existence since 1930 and several employees have approximately fifteen years of prior service which would normally be accredited towards their retirement. We paid $116 for that survey and the cost was estimated to the District for prior service about $800 a year which we would have to pay over the next 25 years, plus approximately $125 for current cost per year. With current contributions this brought it up to $1,600 or $1,700 that the district is required to pay directly each year, aside from the contributions of employees. The San Joaquin Local Health District also worked on this problem and discovered that in drafting the amendments that something had been overlooked. The contract between the District and the System had to be by executed by an ordinance according to what the law said, because it was originally designed for cities. However, special districts do not have power to enact ordinances. There was a considerable amount of discussion over this and correspondence with attorneys and the Attorney-General. It was finally ruled by the Attorney-General that the intent of the Legislature was clear, and adoption of the contract by a resolution would be legal. However, the Attorney for the San Joaquin Local Health District decided that while such action would probably be approved by the Supreme Court, nevertheless there was the possibility that a taxpayer might sue the trustees individually for misuse of funds, and that in such a case the Trustees would have to defend themselves with their own attorneys at their own expense. We would possibly put our trustees to considerable jeopardy and a certain amount of expense. As a result, we took no further action and waited for the 1945 Legislature to pass an amendment which would permit local agencies to enter this contract either by adoption of an ordinance or the passage of a resolution. That went into effect in August 1945. Immediately after that it was necessary for us to have a new actuarial survey because our personnel had changed in the interim, and this cost us something over $100. Since that time we have proceeded with the various forms in order to get our people into the System. It was necessary for our Board of Trustees first to adopt a resolution of intention to enter the State Employees' Retirement System. That was duly adopted and we finally got through the red tape of the survey, estimate of cost, etc. Then in December, 1945 our employees were called into the office, an election was held on ballot forms furnished by the System, the ballots then sealed up, counted at a subsequent meeting of the Board. All were in favor and later we passed a resolution approving the contract. The contract was signed and sent to the System. It is now regularly in effect beginning January 1, 1946.

The System sets up certain deductions which are taken from the pay checks of the individual employees. The amount deducted is a percentage according to the age and sex of each employee at the time of entering the System. In the case of those who have been with us more than six months, their membership is effective 1-1-46. All others do not come into actual membership until they have been employed six months.

This money is deducted from the employee's pay check just as the income tax is deducted. Remittance of the employees' contribution is made monthly to the System, together with the amount of money which the District contributes. The District's contribution is nearly 6% of the total pay roll of those participating. The employee's contribution ranges from about 4% to about 8%. The maximum salary on which any deduction can be applied is $416.66 per month. Anything above this is exempt from deduction.

In addition, once or twice a year the District pays to the System upon demand the sum of $2 per member for administrative expense, and also pays the fixed sum to take care of back prior service benefits for the employees -- $800 or so over a period of 25 years.

The benefits received depend upon the length of service and the average salary over the last few years of service. Retirement is permissable at 60 and 20 years service, and is compulsory at 70 regardless of the number of years of service. The men who start younger with the System receive a larger pension upon retirement than those who start in later and have to retire because of the retirement age limit. In general after 20 years service an employee receives about 2/7 of the last three years' average salary. After 30 years, he will get nearly 1/2 of his average salary over the last few years of service.

In spite of all the legal red tape we had to go through to get this retirement matter made available to you, I still think it is of value and it will work towards better stability and longer tenure on the part of employees. We no longer feel that when we get too old to do good work we are to be kicked out on our ear and that nobody cares a hoot about what becomes of us.

I do not know how many districts have taken any steps as yet to enter the System. It is a thing that might well be taken up by your Board of Trustees if this has not already been done. Full or partial allowance for prior service can be given. Our board is giving only half.

Mr. Robinson: Supposing someone works for the District say 5 or 10 years and then quits. What happens?

Mr. Gray: He receives what he has paid in himself. If he is physically incapacitated at any time and is unable to go on with his work, there is a provision also whereby he gets a certain amount. And if he dies at any time during his service for this district he receives a death benefit that is fairly substantial. There is no death benefit unless he has been a member of the System for a year.

Prof. Herms: Harold made a remark that disturbed me. He made a remark about too much red tape. I don't like that. I appreciate all the fine things he has done all through the years in the matter of mosquito control and the forward look he has always had. I want you to know it. I hope he will see a number of years of service yet and that we'll have him here with us active at these conferences.

As a Trustee of the Alameda County Mosquito Abatement District, I am concerned with doing the best possible job with the tax dollar. A good job can only be done by good men and women. This costs money and is an addition to the taxes. The trustees of the District cannot be too close about salaries if they are to have adequately trained men in mosquito control. To get good personnel it has to be paid for. We have been talking about adequate training. It is important. We need adequately trained men, and if we are going to get them we must see that there is a proper and adequate salary scale and, added to that, the question of future security must be carefully considered and provided for. It is a vital question. My own retirement stares me in the face and that is at least one reason why I feel so strongly on the subject. It has brought it home to me very realistically. For you younger fellows, this matter of security is important and I hope that the trustees in all the districts will do something about it. See that it comes to their attention.

Mr. Bumiller: I would like to congratulate the District that has already established their connection with the Retirement System. I think it is a very worthy cause.

Mr. Gray: Ernest Campbell tells me that in Contra Costa County there is a method by which his district has been able to enter the county retirement system.

Dr. Reeves: We will now have a paper by Gjullin and Yates on the survival of Aedes eggs in nature. The paper will be presented by Mr. Gjullin.

THE SURVIVAL OF AEDES VEXANS AND AEDES LATERALIS EGGS IN NATURE

By

C. M. Gjullin and W. W. Yates[1], Bureau of Entomology and Plant Quarantine, Agricultural Research Administration, United States Department of Agriculture

The annual freshets of the Columbia and Willamette Rivers, which usually occur in May or June, flood large willow and cottonwood flats that border these rivers in a number of places. These floods produce large hatches of Aedes vexans (Mg.) and A. lateralis (Mg.) from the eggs laid in these areas during previous summers.

The maximum height of the flood crest on these rivers varies considerably from year to year. In 1894 the Willamette rose 33 feet above its normal level and flooded a large portion of the city of Portland (Oreg.). This record has not been equaled on this river, but rises of 20 to 24 feet occur every few years. These rises are frequently followed by low water for several years, so that the eggs of Aedes vexans and A. lateralis, which are laid on the moist soil bordering these flood waters of high-water years, may not be flooded again until several years later. The percentage of eggs which survive during such periods determines the size of the mosquito population when the next flood occurs, and may also affect the survival of these species in isolated areas which are not flooded annually.

Large hatches of larvae from areas which have not been flooded for more than a year of common occurrence, but they seldom provide any information on the ability of the eggs to survive because mosquitoes from nearby breeding places have usually been present and could have laid these eggs during the previous summer.

To obtain more accurate data on the survival of Aedes vexans and A. lateralis eggs, top soil to a depth of 2 or 3 inches containing large numbers of eggs was transferred from a willow swale to a screen cage on nearby higher ground, which was above the flood level of the river. This swale, which is located on Deer Island in the Columbia River, was flooded in 1934, and the soil was transferred to the cage in May 1935. The eggs with the exception of any that failed to hatch in 1934, were therefore all laid from May to September of that year.

The cage was 20 feet long by 14 feet wide and 2 feet high, and was shaded by willows and cottonwoods. The top soil inside the cage was removed to a depth of approximately 2 inches, and 1/2-inch mesh

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1. H. H. Stage was in charge of this experiment until 1940. An analysis of the figures on egg hatching was made by F. M. Wadley.

screen was then laid down to prevent moles from burrowing up through the soil containing the eggs. A 16-mesh screen was used on the sides and removable roof section to prevent mosquitoes from laying eggs on the soil after it had been placed in the cage.

The soil containing the eggs was mixed and placed in the cage to a depth of 3 or 4 inches. Cheesecloth, which was placed over the top of the cage during the summer months, and leaves which accumulated over it provided shade comparable to that under field conditions.

Twelve samples of soil from the cage were brought to the laboratory in June and September of each year. A sample consisted of 1¼ quarts of soil and debris. These samples were a mixture of soil taken from a number of different places in the cage. Half the samples were flooded at once, and the other half were left at room temperature of approximately 70° Fahrenheit for 7 days before they were flooded. After each series had been flooded and the hatching larvae had been counted, the samples were dried at room temperature for several days and were then reflooded. This procedure was repeated until no further hatching occurred.

The percentage of each species present in each sample was determined on the basis of 20 larvae taken at random from the sample. The total yearly hatch of *Aedes vexans* and *A. lateralis* per sample for both the samples flooded at once and those that were dried before flooding is shown in Table 1. The average annual hatch per sample is shown in Figure 1. Although the soil was mixed when placed in the cage

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Figure 1. Average hatch of *Aedes lateralis* and *A. vexans* eggs per sample from 12 samples of soil taken in June and September of each year.

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the variations from the general trend which occur in the number of larvae produced per sample per year are probably due largely to uneven distribution of the eggs in the soil.

Table 1. Total number of *Aedes vexans* and *A. lateralis* larvae hatching from 12 samples of soil taken from the cage in June and September of each year, 1935-41.

Aedes vexans

Year	Samples flooded immediately		Samples dried before flooding	
	June	September	June	September
1935	1052	787	1305	936
1936	1132	184	1531	174
1937	205	33	518	222
1938	11	7	0	18
1939	6	0	6	3
1940	0	0	0	0
Totals	2406	1011	3360	1353

Aedes lateralis

Year	Samples flooded immediately		Samples dried before flooding	
	June	September	June	September
1935	1442	101	655	267
1936	31	28	100	23
1937	7	3	20	23
1938	701	126	449	187
1939	951	347	706	265
1940	76	6	47	8
1941	4	0	1	0
Totals	3212	611	1978	773

A continuous decline in the average hatch per sample of both Aedes vexans and A. lateralis occurred from 1935 to 1937. The decline in the number of viable A. vexans eggs continued in 1938, but there was a sharp rise in the number of viable A. lateralis eggs. In 1937 a hole was torn in the top of the cage by a broken limb from one of the nearby trees, and when the cage was visited again in June of 1938 many mosquitoes were on the wing and could have entered this hole and laid eggs. If this was responsible for the increase in the number of viable A. lateralis eggs, then A. vexans females, which were also present, apparently did not find the soil in the cage a suitable place to lay eggs.

A similar decline in the number of viable A. lateralis eggs occurred from 1937 to 1941. It seems probable, therefore, that new eggs of this species were laid in the cage in 1937, and that the maximum period of survival of these eggs is from 3 to 4 years. However, we have placed soil with eggs in another cage, and the soil samples from this cage, which are now being flooded annually, should provide more definite information.

Large numbers of Aedes vexans eggs were found to survive in this experiment for more than 3 years, and 3 eggs of this species that hatched from samples taken in September, 1939 were 5 years old.

Information on the number of eggs present in the soil of the cage, and on the number of those that would hatch, was obtained in 1939 and 1940, when eggs were removed from this soil and flooded. The eggs were separated from the bulk of the soil by a separating machine developed by Gjullin[1] and were then removed from the remaining soil with a camel's hair brush under a low-power microscope. Seventeen of the 38 Aedes vexans eggs and 63 of the 198 A. lateralis eggs recovered in 1939 hatched when flooded with asparagine-phosphate solution, as used by Gjullin, Yates and Stage[2]. Moreover, 2 of the 5 A. vexans eggs and 8 of the 16 A. lateralis eggs recovered in 1940 hatched when flooded with

1. Gjullin, C. M. 1938. A machine for separating mosquito eggs from soil. U. S. Bur. Ent. and Plant Quar. ET-135, 4 pp. (Processed.)

2. Gjullin, C. M., Yates, W. W., and Stage, H. H. 1939. The effects of certain chemicals on the hatching of mosquito eggs. Science 89: 539-540.

this solution. About 70 per cent of the eggs of these species normally hatch under this treatment.

Some information on the dormancy of the eggs of these species may also be obtained from a comparison of the numbers of eggs hatching from different soil samples flooded in this experiment. The samples taken in June of each year did not produce any additional larvae when they were dried and reflooded. This shows that all the eggs had emerged from winter dormant condition by this time of the year. Samples taken in September did produce additional larvae in the second and third refloodings, but figures in Table 1 show that the total hatch in these samples was less than half as large as the hatch in the June samples. These September samples were kept at 70° Fahrenheit for 2 to 4 weeks, while they were being dried and reflooded. This period of warm temperature did not bring the remaining eggs out of their dormant condition.

LIST OF ILLUSTRATIONS

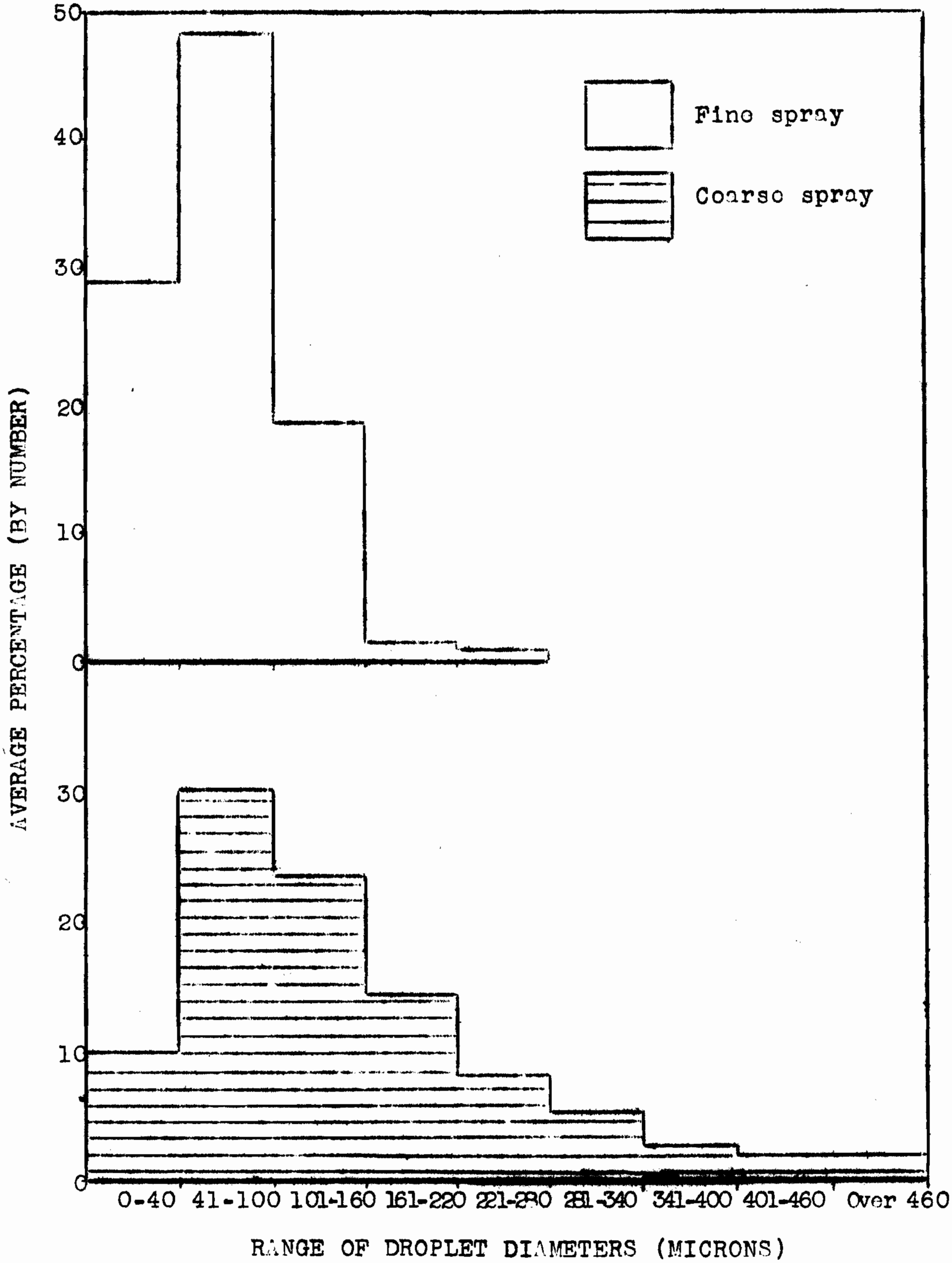

Figure 1.--Droplet spectra obtained with a 5 per cent DDT solution and fine or coarse nozzles.

Dr. Reeves: Thank you, Mr. Gjullin. I will now turn the meeting back to Mr. Robinson.

Mr. Robinson: We will now proceed to the presentation of a paper by E. E. Horn of the U. S. Fish and Wildlife Service, on "Mosquito Control and Migratory Water Fowl Management."

(Note from Editor -- A letter was written to Dr. Horn on March 1, 1946, asking that this discussion be prepared in written form. On May 9, 1946 the copy had not been received).

Mr. Gray: For a long time in the past various and sundry duck hunters have accused mosquito abatement districts of being this and that -- none of them nice -- and in their enthusiasm they have gone pretty far in reckless denunciation. I think that was a serious mistake due to misunderstanding on both sides of the argument. There has never been any real difficulty between the men who have the duck clubs and the mosquito control people where the work is done on a sound biological basis. We in Alameda County havy always been able to get together and work something out satisfactorily.

We have at least two measures which are practically perfect for the control of breeding on extensive flooded areas. They have not been used sufficiently.

If you maintain constant levels in flooded areas and stock them with Gambusia fish and provide channels by which the fish can penetrate to all parts of the flooded area, you will have relative freedom from mosquito breeding; enough so that it is not a serious problem.

We also have a method which is used in Solano County and also Alameda. We call it controlled re-flooding. We re-flood and re-drain until we hatch out all the Aedes eggs. Then we have such a little breeding left that it is simple to mop it up with spraying. I don't think the solution is to go around spraying the duck clubs with oil or larvicides. It is rather a problem of managing the water, and setting up auxiliary control measures with Gambusia or other fish so that we do not have this problem of unregulated fluctuating water levels.

We have some rather tough problems. One club floods in July or August and their pump is too small. The volume of water is not large enough to flood the area rapidly, and as a result we have a gradually rising water level of a period of two to three months. If they would get a larger pump it would save us lots of trouble in spraying.

Mr. Gray: I would like to suggest that Col. Morrill is here from Burma and it would be good to hear from him.

Col. Morrill: I went out four years ago to work on sanitation along the Yunan Railway. There were three of us sanitary engineers. My own experience has been in sewerage. The work was designed and done by the Chimese Government with technical advice by the Public Health Service. Transportation was so difficult that it was quite impossible to cover the entire area. It was decided to divide the work into three parts and put one engineer in responsible charge in each part. He had to look after everything. They put me where the malaria situation was least serious. Then I was transferred to India for a year and a half. I worked on malaria problems for a while and was then transferred to water supply for the Army, and only for the malaria work incidentally.

We weren't allowed to tell our relatives where we were. All that a man could say was that he was in India and that is a big place. Everybody knew a good share of the operations were in Assam. One entomologist used his knowledge of mosquitoes when he wrote home saying he had been examining various species and then described Anopheles minimus which is found in north-east India and Assam.

When we built a highway we would excavate borrow pits to build up the road base. The coolies got paid so much for a hundred cubic feet, one foot deep and ten foot square. The result was that we made thousands of pits which had no drainage.

In Assam the tea estates have done a great deal of work in malaria control. Their methods are very interesting and their approach so different from the Army. In Assam Anopheles minimus breeds in the sun and in slowly moving water.

Mr. Robinson: I am sure the Colonel will be glad to answer any questions you may have.

Mr. Blumberg: Did you use DDT?

Col. Merrill: It was very new at that time. I went to India in May of 1942 and came back here in January 1944. I went to a course in Florida at that time. DDT was very scarce. Its use in malaria control was highly restricted information. Pyrethrum was not so difficult to obtain in India then as it was in the United States. We would get it from British sources. DDT may have been used since. I think a good deal of oil was used.

In the Ganges Plain of east central India there is a very heavy rainy season in July, August and September. There is a great deal of rain in Calcutta. In April and May it is like a desert; there is no rainfall. That is before the monsoon season starts. They build tanks which are earthen reservoirs. They depend on that and the rainfall. One airfield where I had charge of water supply was very much scattered, because we were afraid of Japanese bombing. The airfield occupied a place about two miles wide and three miles long. No buildings were closer than fifty feet and we tried to have no two in line. That made the camp occupy a large area. The officer in command said to get rid of the water tanks. There were about 400 of those and it would cost a lot of money to fill these up. Finally he was talked out of the idea.

Mr. Robinson: Thank you, Colonel Merrill.

I will now appoint the Committee on Education and Registration of Mosquito Control Personnel suggested by Mr. Gray.

Chairman, Herms
Members, Washburn, Pangborn, Peters and Freeborn

Mr. Gray: I have a Resolution I would like to present:

"WHEREAS, for the past thirty-six years or more William B. Herms has been the leader in both the scientific and practical phases of mosquito control on the Pacific Coast, to the great benefit of the people of this area, and has been one of the founders of medical entomology, and an inspiring teacher of many students who have rendered valuable service also in this field and

"WHEREAS, in September of 1946 William B. Herms retires as Professor of Parasitology in the University of California, now therefore

"BE IT RESOLVED, by the California Mosquito Control Association, that in recognition of the fine public service rendered by William B. Herms, the officers of this Association be directed to purchase and present to Professor Herms a suitable gift with which to partially express to him our high personal regard, and that, further, this group do now stand and wish him many years of happiness and continued usefulness to science and man's welfare."

The foregoing resolution was adopted by acclamation and a rising vote.

Mr. Robinson: The meeting will now recess for lunch.

The meeting re-convened at 2:00 p.m.

Mr. Robinson: We are to begin this afternoon with a paper by Maurice H. Coblentz on "Surplus Property Utilization in the Field of Mosquito Control."

Maj. Coblentz: I have taken the liberty of changing the assigned title and will talk on the matter of acquisition rather than utilization of this material.

THE ACQUISITION OF SURPLUS PROPERTY FOR USE
IN THE FIELD OF
MOSQUITO CONTROL
by
Maurice H. Coblentz, San. (R) U.S.P.H.S.

Since it is the primary purpose of this discussion of Government surplus property to assist the members of this association in obtaining needed supplies and equipment for use in mosquito control, there will be no attempt to discuss its utilization. I am sure that most of you have need of such supplies and equipment, and that the acquisition thereof, at costs considerably below normal, will therefore be of special interest.

It is proposed, therefore, to introduce the subject for general discussion with brief statements concerning the surplus property regulating agency, S.P.A., the origin and sale of surplus, government priority and preferences, Regulation 14 and the function of the Federal Security Agency through its subsidiaries, the U. S. Office of Education and the U. S. Public Health Service as an assisting agency.

Surplus Property and the S.P.A.

Surplus Property is, in general, what the Government owns, but does not need. The estimated total value of such surplus property created by World War II ranged into billions of dollars. It is estimated that during the fiscal year July 1945 thru June 1946 Consumers and Capital and Producers goods which cost the government approximately 23 billion dollars will have been declared surplus. Surplus property includes almost every kind of material or product, more than 1 million different items, some unknown to ordinary trade.

The Surplus Property Administration, S.P.A., is the over-all agency regulating the disposal of surplus. S.P.A. does not sell any property. It is primarily a coordinating, regulating agency, created by the Surplus Property Act of October 3, 1944.

Origin and Sale of Surplus

Owning Agencies, chief of which are the Army and Navy, declare surplus because they no longer need it, not because it is without usefulness.

Disposal Agencies are Federal agencies designated by S.P.A. to sell property under declaration and disposal procedures based upon the provisions of the Act. Surplus property is sold through different disposal agencies, each disposal agency handling a different broad category of property, so that there will be no duplicating sales. The law limits disposals of certain items to specific agencies -- for example, merchant ships may be sold only by the Maritime Commission.

Order of Government Priorities

Government agencies have priority to buy surplus property as follows:

1st. Federal agencies.
2nd. States, their political subdivisions, and instrumentalities. Non-profit institutions which are operated by States, local governments and their political subdivisions are included in this 2nd priority.

Preferences

The Act also authorizes preferences for certain classes of buyers. S.P.A. regulations govern the order in which these preferences operate, and the types of property involved. Real Estate is separate and is classified by S.P.A. before decision upon the appropriate disposal agency for handling. These preferences involve education, public health and charitable institutions, farmers, veterans and small business. Of particular interest to this Association are the preferences coming under the provisions of S.P.A. Regulation 14.

S.P.A. Regulation 14

Section 13 of the Surplus Property Act of 1944 provides generally for transfer of surplus property on the basis of need to non-profit institutions and instrumentalities so that they may have the opportunity to fulfill in the public interest their legimate needs, and that surplus property that is appropriate for school, classroom or other educational use, and surplus medical and sanitation supplies, equipment and property suitable for use in the protection of public health, including research, may be disposed of at a value which takes into account any benefit which has accrued or may accrue to the United States from the use of such property.

In compliance with the requirement of Regulation 14, the Federal Security Agency has submitted to the Surplus Property Administration certified lists of public-health, educational and other non-profit institutions and instrumentalities eligible for the benefits provided. Such lists are subject to revisions from time to time. Similarly criteria by which to determine legitimate needs of non-profit institutions and instrumentalities have been developed and procedures for applying such criteria and eligibility to claimants are now in use by representatives of the Public Health Service in the District Offices and at regional offices of the War Assets Corporation.

Any non-profit institution whose application is approved by Federal Security Agency, or on appeal by the Surplus Property Administrator, shall be entitled to acquire from disposal agencies any surplus property available for disposal, at the fair value of such property, and in lots not smaller than the smallest lots consistent with commercial practice. Such fair value shall not be greater than the lowest price which is offered to any trade level at the time of acquisition by the non-profit institution or instrumentality.

Property already advertised for public competitive bids or for sale at auction or for immediate purchase at a fixed time, and property specifically selected by a prospective purchaser, shall not be considered available. Orders from non-profit institutions shall not be filled out of property reserved for Government agencies and State and local governments and their instrumentalities.

Disposal agencies shall allow from the fair value a discount of forty (40) per cent upon orders by or for educational or public-health institutions or instrumentalities based upon approved applications. Disposal agencies in cooperation with Federal Security Agency are adopting procedures which will allow non-profit institutions and instrumentalities to receive notices of what surplus property is available or offered for sale within the area in which the offering is made. Non-profit institutions and instrumentalities will, upon request, be put on mailing lists where such lists are used to offer property for disposal.

For the purpose of meeting its responsibilities in the surplus property program the U. S. Public Health Service has assigned trained commissioned officers and civil service personnel to the central office of Surplus Property Utilization in Washington D.C., in its District

Offices and in each of the Regional Offices of the War Assets Corporation. The U.S.P.H.S. District Office is located at 1407 U. S. Appraisers Bldg. and the Regional Office W.A.C. at 30 Van Ness Avenue in San Francisco. The latter office is the most direct location to request placement on the mailing list of the disposal agency, to make application for purchase at discount, and to submit purchase orders or letters of intent to purchase including lists of items desired.

Since the class of claimants and potential surplus property represented by this Association is that of Public Health, it will be helpful to supply the membership with copies of current instructions as to how to obtain information about available surplus property, how to apply for discount and how to prepare an order and follow it through. A limited number of these instructions are available today in the possession of your Secretary-treasurer, Mr. E. Chester Robinson for distribution.

Mr. John T. Norgaard, Public Health Representative in charge, at the Regional Office 10, War Assets Corporation is attending this conference with me this afternoon and I am going to call on him to give you a brief statement of his function in the W.A.C. office and tell you how to find out what items are available, how to apply for certification of eligibility to purchase at discount, and how to place a purchase order.

(Note: The editor regrets that the questions and answers following this paper were so rapid fire, and the speakers unidentified, that the stenographer was unable to make a transcription satisfactory for reproduction.)

Mr. Robinson: We are now to have a paper on "Wartime Aviation Quarantine" This will be given by Professor Herms' son, W. M. Herms.

WARTIME AVIATION QUARANTINE

by

W. M. Herms, Specialist, Agricultural Extension Service
College of Agriculture, University of California

It is a pleasure and a privilege to speak before this group at your annual meeting. I have followed more or less closely the developments in mosquito control in California over a long period of years through the stimulus received from the founder of this work in California, Prof. William B. Herms. After a period of training at the Naval Medical Center (Bethesda, Maryland) and before leaving for military duty overseas as a Naval Officer I was fortunate to be able to spend some time with Thomas Mulhern of the American Mosquito Control Association, visiting the now famous New Jersey mosquito abatement projects. Their development of ditching equipment at that time, and their tide circulation program on their marshes was of particular interest to me and are noteworthy. I have with me a few snaps and plans of some of this equipment, including their tide gates and light trap, should any of you like to see them.

Now to the subject of this paper "Aviation Quarantine". In presenting this subject I wish to provide some historical and geographical background.

HISTORICAL:

The word quarantine as you know is derived from the Italian word "quarantina" meaning a period of forty (40) days. In otherwords all ships coming into Italian ports in the early days were isolated and placed under quarantine for forty days. We have come a long way since that time in types and speed of transportation. Also great progress has been made in our methods of prevention of diseases and particularly control of disease bearing insects.

Where surface travel for example from the Phillipines or the Orient was measured in months and days, now with aviation this same distance is covered in hours and minutes. Where most adult insects such as mosquitoes for example, would most probably complete their life span or be destroyed on a long ocean voyage, these same insects can now travel by plane intact and can be taken alive from such planes as our records show.

Geographical:

If a map of the Pacific Ocean area were placed before you on which were indicated the names and locations of the various endemic tropical diseases, you would find such familiar names as malaria, filariasis, dengue fever, the dysenteries, cholera, scrub typhus, plague, encephalitis, yellow fever, yaws and a number of others. Scanning these again we find that they are largely insect bornediseases. The mosquito is the vector of malaria, dengue fever, filariasis, yellow fever and encephalitis. Filth flies are mechanical transmitters of cholera and some of the dysenteries, the flea transmits plague and so on down the line. With American personnel deployed over most of this vast area and insects playing a major role in disease transmission, I think you can visualize the problem. Insects were playing a major role in the Pacific war and constituted a threat to the successful prosecution of campaigns.

In further examining a map of this kind we find that certain island groups and areas do not have the anopheles mosquito, but the threat of introduction was ever present. Also certain sections or islands would have dengue fever and its vector, while adjoining islands also with the efficient vector would not have an epidemic, a comparable situation prevailed with dysentary. This created a situation where those concerned with environmental sanitation including insect control were sitting on a powder keg which might explode at any time and sometimes did.

Military Responsibility:

The Navy in World War II largely because of enormous aviation development was required to maintain a considerable number of land base installations in addition to its ships afloat. This was a relatively new procedure for this branch of the service. With this development came new problems and one of them was "How to prevent the spread, particularly of insect borne diseases and their vectors, from base to base and island group to island group."

A three man Commission representing Army, Navy and the United States Public Health Service, after a world wide study of these problems, laid down certain general aviation Quarantine procedures which were similar for Army, Navy and the Public Health Service. The fundamentals outlined by this Commission were essentially those already in use in the Pacific.

The Navy early realized the potential hazard of insect transmission and disease spread by plane, and set up a cooperative program with the existing agencies. Later when traffic became heavy and personnel short, those agencies asked the Navy to carry on. When this occurred a four point Navy Aviation Quarantine program was set up.

Essentially these four points were:

1. Quaratine of Personnel
2. Plant and Animal Quaratine
3. Plane Quarantine (Plane spraying)
4. Base Sanitation

<u>The Aviation Quarantine Program</u>

To elaborate on each of these four points in relation to the goal of disease prevention -

1) Quarantine of Personnel - Some of the precautionary measures taken to keep at a minimum the spread of tropical diseases by personnel included;

a) <u>Medical Certificates</u> were required on all passengers traveling by the Naval Air Transport Service Pacific Wing, (N.A.T.S.), thus covering better than 90% of all transoceanic passengers carried by the Navy. This later was modified to allow personnel to move from the Hawaiian Islands to the Mainland without certificate. Flight personnel were under the surveillance of the flight surgeon.

b) <u>Immunization</u> was required for protection against certain tropical diseases, the requirements varied depending upon the area to which the individual was destined.

c) <u>Aircraft Quarantine Declarations</u> were required on all N.A.T.S. planes arriving in Pearl Harbor. Clearances were issued on planes departing from Pearl Harbor. I will comment more on this point in a moment.

(2) <u>Animal and Plant Quarantine</u>:

The shortage of trained men and time did not allow a selective agricultural and animal Quarantine consequently an embargo was placed on all plant and animal introductions by plane from the south or west. The Bureau of Entomology and Plant Quarantine handled plant inspections to the mainland with the aid of the Navy.

Because the Hawaiian Islands at that time were the focal point for all transoceanic aviation traveling from the mainland to the west and vice-versa; the baggage inspections were accomplished at Honolulu. It was here that the main barrier was set up to stop the flow of agricultural pests in either direction.

(3) Plane Quarantine

a) (Spraying of Planes) at the outset in an effort to have an effective safeguard against insects traveling by plane - a two spray program was inaugurated, spraying upon departure from each island group and spraying prior to arrival at the next island group was required. Later as crews and personnel became conscious of the need for this measure only one spraying between island groups was generally practiced. However the two spray program continued in force almost to the end of the war at Pearl Harbor. The aerosol bombs, one and two pounders were used for this purpose in expended concentrations up to 16 seconds per 1000 cubic feet of air space. The length of spray time varied with the type of plane.

b) Collection of insects from arriving planes was considered as routine Quarantine procedure. This was accomplished in so far as trained men were available.

(4) Base Sanitation

a) Realizing that a base that was free of insects and disease could not transmit them to another base or island group, insect control and sanitation was particularly stressed. Transient barracks were freed of bedbugs, using DDT and flies and mosquitoes were controlled by sanitary procedures as well as DDT sprays.

b) Inasmuch as flight kitchens, which dispense food to all parts of the N.A.T.S. Pacific system, are a potential focal source of infection, emphasis was placed on keeping them free of flies and in sanitary condition.

c) One method used in checking the efficiency of our work was by placing the New Jersey type light trap at various strategic places, such as air bases and ports to aid in intercepting possible introductions. A mass of local material was trapped. Over nine hundred mosquitoes mostly Culex quinquefasciatus were trapped at one location in one evening. An analysis of all this material would be interesting. The Hawaiian Sugar Planters Association Entomologists have analyzed some of these findings.

Entomological Phases of Quarantine:

The development of the entomological phases of an Aviation Quarantine procedure is based on the premise that insects do travel by plane.

On records and collections made by the Navy Entomological Unit No. 51 at the Naval Air Station Honolulu in over a year's time, it is known that insects do travel by plane and sometimes in considerable numbers. In a recent letter from one of the boys in this unit he wrote that they had made what they believed was a record catch, namely seven hundred insects from one plane. It is true that many of these insects are not harmful either from a medical or an agricultural standpoing but there is a large enough percentage of dangerous pests traveling to make those who are concerned with the security and health of the nation and its agriculture to be justifyably concerned.

An example of the possible danger or better still the value of an Aviation Quarantine program is the fact that from collections also made by the above-named unit ten species of mosquitoes not present in the Hawaiian Islands were collected from arriving planes in numbers. Also flies in large numbers were intercepted on planes originating from known cholera and dysentery areas.

In addition other insects not endemic to the Hawaiian Island groups were continuously brought by plane. Almost without exception all specimens collected from planes were dead indicating the effectiveness of spraying operations. It was not our function nor was there time to conduct research on the significance of the introductions above mentioned. However a partial tabulation of the mosquitoes according to genus and species which were found on planes during a limited period are as follows: Aedes: taeniorhynchus, vigilax, albopictus; - Anopheles: punctulatus; - Culex: annulirostris, jepsoni, quinquefasciatus, pipiens, tarsalis, and sitiens. Inasmuch as there were considerable numbers of dead unidentified specimens it is safe to assume that this lift for this particular port of entry could be much larger.

Tribute to Aviation:

What I have said is no indictment against aviation. The record of aviation in this war is clear. The flying of needed medical supplies (penicillin, whole blood, plasma, etc.) with the subsequent saving of lives is a proud saga of aviation.

Again I wish to express my appreciation for this opportunity of being present with you. Good luck in your fine work of 1946.

Mr. Gray: Did you have any trouble with any of the passengers in spraying? I am thinking of allergies. I am very sensitive to dry pyrethrum. It affects my sinuses.

Mr. Herms: So far as we know we didn't have anything of the kind which could be definitely attributed to the spray. Some of the new aerosols come in flavors, they are perfumed. Geranium, for instance. Lots of the planes were large transport planes. We didn't find any live mosquitoes. We traveled at a high speed and the air pressure at this elevation would have a tendency to eliminate anything on the outside.

Mr. Robinson: We are now to hear a paper by Stanley F. Bailey, Associate Entomologist, University of California at Davis, who will tell us something about mosquito control in the Marianas Islands.

Dr. Bailey: I have not prepared a paper, and shall therefore speak informally.

Try to imagine yourself with a group of South Pacific Islands in which it is your job to control the mosquitoes. The first thing you must do is to find out what kinds of mosquitoes are present. The next thing is to decide what control methods are necessary. Then you have to go out and do the job.

As there were still some Japs on these islands, we started out with a firearm in one hand and a dipper in the other to make the initial surveys. We had a full-blown epidemic of dengue on our hands, and we tried to find out which areas had many cases and which areas had few.

We tried first to kill off the adult mosquitoes in and near quarters and native areas, and then to set up priorities for the various jobs to be done.

Much of the mosquito breeding occurred in such containers as water barrels, bucket, helmets, etc. Water barrels were controlled by covering with treated burlap, which would last for four or five months. A great deal of detailed spraying was necessary to control Culex quinquefasciatus. In addition, we did a lot of broadcast spraying by airplane to control other pest mosquito breeding, using DDT after it became available in sufficient quantities.

In the mixing, handling and spraying of DDT we did not have any cases of poisoning either among the men working with it, or among the island population. The Sea Bees worked in it with their clothes off. If a man happened to be under a plane and got actual drops of spray on his skin he sometimes developed a dermatitis which disappeared in 24 hours.

In civilian work it will be unnecessary to take the risks we necessarily did in handling DDT, but we had no trouble with poisoning. We were able to get good results in controlling mosquitoes and flies, in an area of considerable rainfall.

(Editor's Note: Much of Mr. Bailey's highly interesting talk was "off-the-record", and therefore only a summary could be presented. He also illustrated his remarks with motion pictures.)

Mr. Robinson: I will now call for the report of the Resolutions Committee, consisting of Mr. Peters, Mr. Mondala, and Mr. Robinson.

Mr. Peters: The Resolutions Committee moves the adoption of the following resolution.

"WHEREAS the Conference of the California Mosquito Control Association has met to consider the newer knowledge on DDT for use as a mosquito larvicide and adulticide, it is concluded that if all reasonable precautions are taken for the protection of personnel in the mixing and use of DDT in oils and organic solvents, experience to date shows no injurious effects to such personnel. It is further concluded that if DDT be sprayed or dusted as a larvicide or adulticide, using standard accepted techniques in amounts to supply the minimum lethal dose to mosquitoes, experience to date shows that injurious effects will not result to biological important insects, fish or animals."

This Resolution was duly seconded and adopted by unanimous vote.

Mr. Peters: The Resolutions Committee moves the adoption of the following resolution:

"WHEREAS the University of California has provided 113 Agriculture Hall as a meeting place for the California Mosquito Control Association February 25 and 26, 1946, it is the unanimous resolution of this body that our sincere appreciation be expressed to the Regents of the University of California and to all others responsible for this consideration."

This Resolution was duly seconded and passed by unanimous vote.

Mr. Peters: The Resolutions Committee moves the adoption of the following resolution.

"BE IT RESOLVED BY the California Mosquito Control Association that we express our deep sympathy in behalf of relatives and friends of two of our close friends and fellow workers, Fred L. Hayes and Robert G. Pirie, who since the last meeting of this Association have been taken from us by death. Their passing is a decided loss to their districts and to mosquito control in California.

"BE IT FURTHER RESOLVED that this meeting shall close with a moment of silence in respectful memory of Fred L. Hayes and Robert G. Pirie, and that a copy of the Proceedings of this Conference be sent to Mrs. Fred L. Hayes and Mrs. Robert G. Pirie."

The foregoing resolution was duly seconded and passed by unanimous vote.

Mr. Robinson: I will now call for reports from a few districts. The first will be by Mr. Lilley on the enlargement of the Merced District.

Mr. Lilley: Our district which began with sixteen (16) square miles, jumped to ninety square miles and then last year to nineteen hundred and ninety five (1995) square miles, taking in the whole county.

The former assessed valuation was around eight and one half million (8,500,000) while now it is sixty million (60,000,000). The rate for the new district is ten (10) cents which by the nature of it will not be enough. It takes in several incorporated towns (some not too large) or we wouldn't have enough to affect any kind of control.

The people in the new district expected results immediately, but as the new district wasn't officially annexed until May there were no funds available. However the assessment was made and we promptly got two protests, one from the Santa Fe Railroad and one from the Southern Pacific Railroad. They both paid under protest, but the Santa Fe has since withdrawn her protest, while the Southern Pacific has not. Should they fight it and beat us, it would mean a lot of tax money refunded which would be quite a job. Therefore we have had to go slow. It definitely cramps our style for the coming season.

I was taken up in an airplane over some of the district on the west side, and if there is breeding in any quantity in what I saw, it will be strictly an airplane job of spraying or dusting. They have an abundance of cheap water, and it is a great dairy country, together with numerous duck clubs, it will require plenty of attention and money. Definitely a station will have to be established over there.

Mr. Robinson: The next report will be presented by Mr. Bumiller on the Ballona Creek district in Los Angeles County.

Mr. Bumiller: The Ballona Creek Mosquito Abatement District went into operation July 1, 1945, after the original, small, District had secured sufficient annexation to increase the valuation to a point whereby a workable budget could be obtained. The small district was first formed in 1943.

The following are the statistics for this District:

Assessed valuation	$31,342,910.00
Area	24 sq.miles
Population	50,000
Rate	$0.0767
#Total levy	$24,040.00
Working Budget	$20,420.00

The Auditor of the County of Los Angeles levied $24,040.00 to take care of delinquent taxes. By July of 1946, due to the tremendous increase in building in the area, the population will probably be about 75,000.

Part of this District contains 800 acres of salt marsh and duck ponds which are subject to tide action. Another portion contains numerous irrigation canals, due to the extensive truck gardening in that area. The remainder is residential in which are found a number of depressions which accumulate water during the rainy season. Scattered about are oil well sumps which are also a problem.

The most troublesome mosquito found there is the Aedes taeniorhyncus but the Culex quinquefasciatus is also prevalent.

Due to the fact that this District began operation during the war we were greatly hampered by the difficulties of obtaining material and equipment. In fact we had to work without a truck for the first six months of operation. However, in spite of these difficulties we were able to reduce the summer flight materially.

Mr. Robinson: The next report will be by Mr. Russell on the Hanford District.

Mr. Russell: In the Hanford district we have many sloughs and a lot of ponds. The sloughs are heavily wooded, and we just have to cut our way through them.

We had many cesspools in the District, but we got a sanitarian appointed, and an ordinance relative to cesspools was passed, requiring them to be repaired or reconstructed so as to be mosquito and fly proof. In three years we have closed over 1500 cesspools, and we had to take only three men before the District Attorney.

For clearing our sloughs we have made our own power flame thrower, with the nozzle on the end of an 8 foot length of pipe. With this we can burn almost anything, including trees, which are burned a little each time until killed and dried.

We are now building a boat with a gas enginge, for more effective work in the sloughs.

We are trying to tell our people what we are doing, and frequently we take community leaders around with us to show them what is done and what we hope to do.

Meetings of this kind are valuable, but I think the practical men should have a larger place on the program, and thus get information of more direct application to our own local conditions.

Mr. Robinson: We will now hear from the new Turlock district.

Mr. Washburn: In Turlock there isn't much to say yet. We were officially set up about a week ago. We go into operation as soon as I am released from the Public Health Service, which is supposed to be this week. We have an area of 340 square miles in Stanislaus county. We are bounded on the north by the Tuolumne River and the East Side District, and extend to the San Joaquin River on the west. I do not know what our main problems will be, but we should have plenty.

Mr. Robinson: We would like to call for reports from all the Districts but time is running out. I wish to announce the appointment of a special committee to act in conjunction with the State Department of Public Health in relation to the allocation of State funds to mosquito abatement districts. The members will be Mr. Geib, Mr. Gray, Mr. Murphy and Mr. Robinson.

Mr. Gray: I request that the Ways and Means Committee meet immediately after adjournment, with the President and Secretary.

Mr. Peters: We intend to contact all district superintendents promptly and give you forms on which to make application for State funds.

Mr. Robinson: I want to particularly thank all those persons who have given so generously of their time to this meeting, and who have presented papers. Some of you have come a long way, and we hope you have enjoyed your stay here.

We will now stand adjourned out of respect for the memory of Fred L. Hayes and Robert G. Pirie.

ADJOURNED

REGISTERED ATTENDANCE AT THE CONFERENCE

MOSQUITO ABATEMENT DISTRICTS

Alameda County

William B. Herms, Trustee
Harold F. Gray, Engineer
Margaret A. Prefontaine, Clerk
Mary M. Gorgas, Inspector
Roland Bendel, Division Foreman
L. Percy Mapes, Division Foreman
Harley A. Dennis, Division Foreman
John A. Duffey, Laborer
Thomas L. Branon, Laborer
Woodrow L. Paxton, Laborer
Herbert Brown, Laborer
Ivan F. Best, Laborer
William C. Hanim, Laborer
Jack D. Rowlett, Laborer
Paul T. Garcia, Laborer

Anderson - None

Ballona Creek

E. J. Bumiller, Manager
H. J. Crawford, Foreman

Carpenteria - None

Clear Creek

Orion Murphy, Superintendent

Coachella Valley - None

Compton Creek - None

Contra Costa No. 1

Earnest Campbell, Superintendent

Cottonwood,- none

Delano

Noel B. Omler, Superintendent

Delta

W. P. Menefee, Superintendent,
D. R. Tyle, Assistant Superintendent

Dr. Morris

A. F. Geib, Superintendent

Durham

D. C. Crandall, Superintendent

East Side

E. Chester Robinson, Superintendent
J. E. Sellers, Inspector
J. M. Crow, Inspector
Nelson Wysong, Inspector
E. Dershum, Inspector
J. W. Allen, Inspector
W. T. Brooks, Inspector

Fair Oaks - None

Fresno

Haus L. Viat, Assistant Manager
R. C. Sturgeon, Chief Inspector

Hanford

E. M. Russell, Superintendent

Los Molinos

Charles Pramme, President, Board of Trustees
F. J. Engelhorn, Superintendent

Marin County - None

Matadero

Gordon W. Mapes, Superintendent

Merced

L. J. Spindt, Trustee
Harold G. Lilley, Superintendent

Napa - None

North San Joaquin

Ernest Campbell, Superintendent

Oroville - None

Pine Grove - None

Pulgas - None

Redding

Orion W. Murphy, Superintendent #

Salt Lake City (Utah)

Don M. Rees, President, Board of Trustees
Robert A. Wilkins, Supervisor

Solano County

Howard Pangburn, Superintendent

Sonoma - None

Sutter-Yuba

T. G. Raley, Superintendent

Tulare

Rolland Henderson, Superintendent

Turlock

Joe Domecq, Trustee
G. Edwin Washburn, Superintendent

West Side

R. H. Coburn, Superintendent

City and County Health Departments

Contra Costa County

Ole J. Hendrickson, Sanitarian
Thomas McMorrow, Sanitarian

Los Angeles City

W. Earle Duclus, Mosquito Specialist

Monterey County

R. M. Abbott, Mosquito Control Officer

Los Angeles County
E. J. Bumiller, Ch. Sanitary Inspector

Sacramento County

Melvin J. Olsen, Ch. Sanitary Inspector

San Jose City

E. O. Hodgert, Sanitarian
John Lucchesi, Sanitarian
R. H. Hubbard, Sanitarian
James Hartley, Sanitarian

Sutter-Yuba Bi-County

Thomas M. Sperbeck, Ch. Sanitarian

Sacramento City

William P. Francis, Sanitary Inspector
H. E. Mulligan, Sanitary Inspector

Kern County

C. F. Baughman, Ch. Sanitarian

State Health Departments

Washington

Mitchell P. Mondala, Sanitarian

California

S. L. Dommes, Jr. Sanitary Engineer
Frank M. Stead, Chief, Div. of Environmental Sanitation
C. F. Snyder, Sanitary Inspector
O. C. Blumberg, Assoc. San. Engr.
R. F. Peters, Entomologist
John R. Young, Sanitarian, Bureau of Adult Health
H. P. Kastberg, M. D., Director, Bureau of Adult Health
E. A. Reinke, Senior Sanitary Engineer

United States Public Health Service

Nelson C. Wagoner, Supervisor, MCWA, Merced
A. V. Sleibert, Liason Officer with 9th Service Command, U.S. Army
George L. Jacobs, Asst. Engineer, Marysville
Richard P. Lonergan, Asst. San. Engineer, Berkeley
Paul C. Henderson, Sanitary Engineer, Fort Douglas, Utah
John J. Pratt, Jr. Asst. San., Terminal Island, Calif.
G. H. Bradley, Senior Entomologist, MCWA, Atlanta, Georgia
Bernard Brookman, P.A. San., San Francisco
G. Edwin Washburn, Asst. San. MCWA, Berkeley#
S. E. Koelz, P. A. San., San Francisco

City of Portland, Oregon

Dorothy McCullough Lee, Commissioner

University of California

Stanley B. Freeborn, Asst. Dean, College of Agriculture and Professor of Entomology
William B. Herms, Professor of Parasitology #
Woodrow Middlekauff, Asst. Prof. Economic Entomology
J. R. Douglas, Asst. Prof. of Parasitology, Davis
J. E. Eckert, Apiculturaslist, Davis
William C. Reeves, Hooper Foundation for Medical Research, Medical School, San Francisco
V. M. Hoskins, Prof. of Entomology
Evelyn L. March, Home Management Specialist, Agr. Ext. Service
James Skilling, School of Public Health
Harold F. Gray, Lecturer in Public Health, School of Public Health#

U. S. Department of Agriculture

Bureau of Entomology and Plant Quarantine

C. M. Gjullin, Entomologist, Portland, Oregon
E. M. Green, Asst. Entomologist, Chico

Miscellaneous

Braun-Knecht-Heimann Corp. San Francisco

O. L. Olden, Jr.

Chemurgic Corporation, Richmond

K. E. Maxwell, Entomologist
S. T. Sutherland
J. J. Jacobs, Vice-President

Shell Oil Company

Leon C. Glover, Entomologist, Modesto
M. H. Dodge, Entomologist

Inland Aviation Company, Los Banos

B. A. Negra
Lloyd Stearman

National Canners Association

E. L. Doule, Sanitarian

Hockwald Chemical Co., Sacramento

W. Fitchen

Pestaway Service, Santa Rosa

Meldon A. Embury, Manager

Insect Research Laboratory, Sacramento

J. D. Kitley, Owner

Philippine Packing Corp., Berkeley

H. M. Curran, Jr. Agriculturalist

Besler Corporation, Emeryville

Paul F. Dresher

U. S. Army

Major W. T. Johnson, Jr. Sanitation Officer, Hospital, Hammer Field, Fresno
Col. Geo. A. Skinner, Medical Corps., Retired
1st. Lt. Floyd C. Stephenson, Entomologist, 9th Service Command Laboratory, Presidio, Monterey
2nd Lt. Thomas N. Tamkuri, San. Engr. Castle Field, Merced
Capt. I. F. Carpolau, Surgeon's Office, HQ VII Corps, Presidio, Monterey
Major H. L. Fruitman, Sanitary Officer, Presidio, San Francisco
Capt. W. J. Glovalsky, M. C., Presidio, San Francisco
Cpl, H. Plonus, Sanitation Section, Presidio, San Francisco
Capt. G. J. Powell, Asst. Med. Insp. Fort Mason, San Francisco
T/4 B. P. Indich, Port Surgeon's Office, Fort Mason, San Francisco
G. C. Duggan, Pest Control (rank and station not given)
Pfc. John O. Thompson, 9206-TSU-TC, Fort Mason, San Francisco
Pfc. Carl J. Balser, 9206-TSU-TC, Fort Mason, San Francisco

U. S. Navy

L. E. Breener, Pest Control, Shop 07, Mare Island
A. G. Keller, Mosquito Pest Control, Industrial Hygiene Section, Mare Island
Lt. (j.g) H. Elliott McClure, Entomologist, HC, Industrial Hygiene Section, Mare Island

(in addition, several commissioned Navy officers were present who failed to register.)

CALIFORNIA MOSQUITO CONTROL ASSOCIATION

Financial Statement

Income

1944

2/29	Cash on hand	$359.21
2/25	Three Cities, M.A.D.	7.50
2/28	Delta, M.A.D.	4.20
3/1	Matadero M.A.D.	10.50
3/6	Solano M.A.D.	11.20
3/23	Compton M.A.D.	4.55
6/18	West Side	5.00
6/23	Dr. Morris M.A.D.	20.00
9/5	T. G. Raley	1.50
	W. T. Ingram	1.50
	Maj. Duncan E. Longworth	1.50
	State College of Wash.	1.50
	H. E. Dodge	1.50
	W. C. Riley	1.50
	Emil Bogen	1.50
10/4	Elwood Seaman	1.50
	Nelson Wagoner	1.50
	Nelson Nysong	1.50
	Grover Force	1.50
	W. W. Farrar	1.50
7/15	San Jose State	6.00
9/21	L.A. City Health Dept.	3.00
		449.16

Expenditures

	Bank Charge	.26
4/29	J.W. Ridcout-operating projector at Conference	12.50
4/29	Smith Bros. Stencils	22.60
6/23	Stamps	5.00
6/26	Palmer Multigraphing Co. white bond paper	39.98
7/3	Zellerbach Paper Co. Columbian Clasp Eps	5.22
7/15	Palmer Multigraphing Co. Mimeo. proceedings	80.72
9/5	Margaret A. Prefontaine transcribing proceedings	40.00
10/5	Alameda M.A.D. stamps used mailing proceedings	20.00
		$226.90

Income 449.16
Exp. 226.90
222.26
.07 bank adjustment
$222.33 on hand 12/31/44

Income

1945

1/1	Cash on hand	222.33
1/5	Alameda Co. M.A.D.	25.00
2/7	East Side M.A.D.	18.60
2/3	Fresno M.A.D.	25.00
2/5	Solano Co. M.A.D.	11.20
2/5	Dr. Morris M.A.D.	25.00
2/5	Tulare M.A.D.	14.00
2/13	Delta M.A.D.	7.15
2/13	Pulgas M.A.D.	7.00
2/16	West Side M.A.D.	5.00
2/16	Matadero M.A.D.	6.50
2/16	Durham M.A.D.	3.00
2/13	Three Cities M.A.D.	7.50
2/13	Mirk Co.	1.50
3/27	Ohio State University	1.50
4/20	Oroville M.A.D.	3.00
4/30	Contra Costa M.A.D.	10.50
5/19	County of Riverside	1.50
6/12	Champaign-Urbana P.H.	1.50
6/19	Whittier College	1.50
6/19	Maison G. DeNavarre	1.50
8/2	Rocky Mt. Laboratory	1.50
8/2	City of Los Angeles	1.50
		402.78

Expenditures

2/8	Fred Hayes - stamps	1.00
2/8	Wedge printing	4.58
3/16	Postage & printing	6.42
10/1	Wedge Adv. Co. printing	11.79
10/1	El Tejon printing	11.13
		34.92

Income 402.78
Exp. 34.92
$367.86 on hand 12/31/45

CALIFORNIA MOSQUITO CONTROL ASSOCIATION

Financial Statement

Income			Expenditures		
1946					
1/1	Cash on hand	$367.86	1/22	Stamps	10.00
2/13	East Side M.A.D.	21.00	2/23	Commercial Printing Envelopes, mimeographing	13.33
2/14	Los Molinos M.A.D.	3.00			$23.33
2/14	Alameda Co. M.A.D.	25.00			
2/15	Delta M.A.D.	10.13			
2/15	Matadero M.A.D.	7.32			
2/17	Pulgas M.A.D.	7.00			
2/21	Carpinterial Pest A.D.	3.00			
		$444.31			

Income 444.31
Exp. 23.33
$420.98 - Cash on hand February 23, 1946