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OBSERVATIONS ON THE USE OF DDT FOR THE CONTROL OF *ANOPHELES QUADRIMACULATUS*

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INTRODUCTION

In the early spring of 1943 the Orlando laboratory of the United States Bureau of Entomology and Plant Quarantine brought to the attention of the Health and Safety Department of the Tennessee Valley Authority a promising new anopheline larvicide. This material was "DDT" [2,2-bis(parachlorophenyl)-1,1,1-trichloroethane], then referred to by the trade name of "Gesarol." Because of the Authority's long experience with airplane dusting, in connection with its routine malaria control program, it was suggested that the research staff of the Health and Safety Department undertake field tests to determine the practicability of airplane application of DDT larvicidal dusts for the control of *Anopheles quadrimaculatus*. Accordingly, a series of airplane dusting field tests was run with this material during the summer of 1943. During the following winter several joint conferences were held by the technical staffs of the Orlando laboratory and the Authority to plan further cooperative studies. As a result, the Authority greatly intensified its DDT research program during the summer of 1944 and expanded it to include laboratory and field studies on house spraying and investigations on the effectiveness of DDT as an anopheline larvicide and adulticide when distributed by airplane as a dust, a spray, or a thermal aerosol. During the course of the studies, advice and field assistance were provided from the Orlando laboratory, the Office of the Surgeon General of the United States Army, research groups of the National Defense Research Committee from the University of Illinois and Columbia University, and the Office of Malaria Control in War Areas, of the United States

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Public Health Service, the latter assigning three of its staff members to the studies at different periods of the season.

The purpose of this paper is to present the results of the studies on DDT carried out in the Tennessee Valley during 1943 and 1944.

USE OF DDT AS A HOUSE SPRAY

STUDIES ON ACUTE TOXICITY

During the winter of 1943 a series of laboratory tests was run to determine the acute toxicities of DDT and pyrethrins for insectary-reared *A. quadrimaculatus* adults. The tests were carried out in a modified Peet-Grady chamber, the inside dimensions of which were 4′ x 4′ x 4′. The inside of the chamber was covered with a heavy kraft paper and was repapered before each test in order to avoid the effects of residual toxicity. The materials were applied as aqueous emulsions with a small specially designed spray gun operated from a hand-pumped pressure tank.

On the basis of a half dozen tests run at varying dosages with each material, the following estimates have been made of the median lethal doses of DDT and pyrethrins:

Material:	LD_{50} *in milligrams per 1,000 cubic feet*	
	Males	*Females*
DDT	7.0	12.0
Pyrethrins	1.0	1.5

It will be observed that male *A. quadrimaculatus* were more susceptible to both materials than were females. Pyrethrins appeared to be seven to eight times as toxic as DDT.

STUDIES ON RESIDUAL TOXICITY

Board tests.—In view of the promising results which had been obtained at the Orlando laboratory, a series of tests was run to determine the residual toxicity of DDT to adult *A. quadrimaculatus*. Six-inch squares of "Beaver Wall Board" were treated with varying dosages of a water emulsion of DDT made from a stock solution containing 20 percent DDT, 20 percent Triton (emulsifier), and 60 percent xylene. At varying intervals after treatment, 1-day-old insectary-reared *A. quadrimaculatus* adults were confined on the boards in half petri dishes for 5-, 30-, and 60-minute periods, following which they were observed for mortality over a 24-hour period. Ten to twenty mosquitoes were used in each test and parallel controls were run on each lot. The boards were stored in a cabinet between tests. The results obtained from the studies are presented in table 1. It will be observed that there were no significant differences in the initial toxicities at the varying dosages, the percent mortality being determined primarily by the period of contact. This suggests that, within the limits of the dosages used, the lethal action of DDT was

TABLE 1.—*Effect of aging on toxicity of DDT-treated surfaces to* Anopheles quadrimaculatus

Age of treatment	Percent mortality in 24 hours							
	5-minute contact		30-minute contact		60-minute contact		Controls	
	Male	Female	Male	Female	Male	Female	Male	Female
40 MG. DDT PER SQUARE FOOT								
New	50	18	100	82	100	100	0	0
1 week	8	7	90	75	100	100	0	0
2 weeks	12	0	83	100	100	100	7	0
4 weeks	11	0	85	38	100	100	0	0
8 weeks	0	0	33	0	75	20	0	0
12 weeks	0	16	50	20	100	44	13	5
16 weeks	0	0	0	0	0	0	0	7
200 MG. DDT PER SQUARE FOOT								
New	80	20	100	100	100	100	0	0
1 week	78	43	100	100	100	100	0	0
2 weeks	20	0	100	100	100	100	20	0
4 weeks	90	55	100	91	100	100	0	0
8 weeks	66	14	100	25	100	71	30	0
13 weeks	45	10	72	44	85	62	14	0
16 weeks	0	0	14	0	52	22	0	0
1,000 MG. DDT PER SQUARE FOOT								
New	82	14	100	89	100	100	22	0
1 week	75	68	100	100	100	100	0	0
2 weeks	50	66	100	100	100	100	0	0
4 weeks	66	80	100	100	100	100	0	0
8 weeks	20	0	100	100	100	100	11	14
12 weeks	16	6	78	83	100	100	14	0
16 weeks	8	0	35	0	100	30	0	7

limited by some physiological reaction, such as the rate of absorption through the feet of the insects. Even at dosages as high as 1,000 mg. per square foot, 100 percent mortality did not result from 5-minute exposures; however, 60-minute exposures to this dosage gave 100 percent mortality as long as 12 weeks after treatment.

Results from a parallel series of tests run with smooth wooden boards were not significantly different from those obtained with the wallboard. Enameled surfaces, however, showed a high initial toxicity but lost this toxicity almost entirely within 2 weeks.

Keg tests.—Further information on the residual toxicity of DDT to adult *A. quadrimaculatus* was obtained through observations with small wooden nail kegs. On April 29, 1944, these kegs were treated at the following dosages with aqueous emulsions of DDT made from the same xylene concentrate used in the board tests: 20, 200, and 2,000 mg. per square foot. The three treated kegs and an untreated control were placed side by side in some heavy woods where high densities of *A. quadrimaculatus* prevailed. At intervals thereafter knockdown times were determined for wild *A. quadrimaculatus* adults obtained from untreated kegs placed in favorable diurnal resting places (*4*) in the same area. The results are summarized in figure 1.

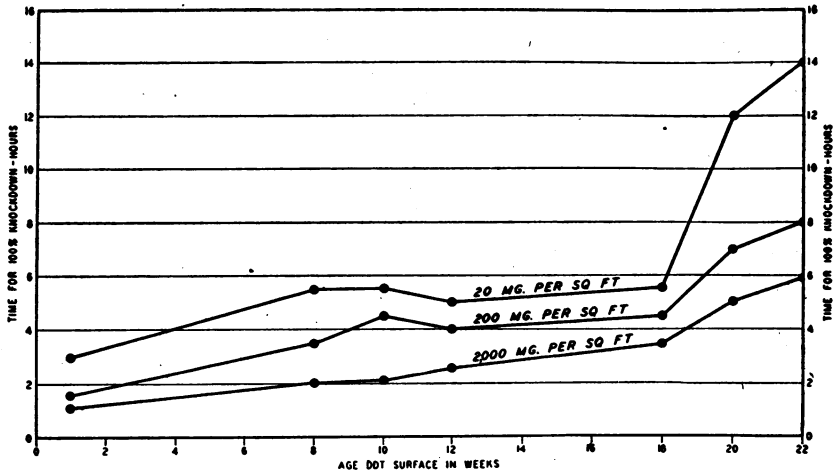

FIGURE 1.—Residual toxicity of DDT-treated kegs to wild *Anopheles quadrimaculatus*.

It will be observed that all of the kegs retained a high residual toxicity for adult *A. quadrimaculatus* for 18 weeks, but at the end of 20 weeks there was a sharp decrease in the toxicity of the keg treated at the minimum dose of 20 mg. DDT per square foot.

Barn tests.—In order to demonstrate the effect of DDT on *A. quadrimaculatus* populations in daytime resting places, three barns with high populations of mosquitoes were chosen as sites for experimental spraying. These barns were all similar in design, each having an open driveway ("dogtrot") through the middle with three stalls on each side. The barns proved to be ideal daytime resting places for *A. quadrimaculatus* adults, being low-ceilinged, dark, and cool. On July 2, 1944, the stalls on the south side of two of the barns (1 and 2) were sprayed with DDT emulsion (made from the 20 percent xylene concentrate) at the rate of approximately 200 mg. of DDT per square foot. The north stalls of these two barns and all of the third barn were left unsprayed. The populations of *A. quadrimaculatus* in these barns were determined by weekly inspections during the 4 weeks preceding and the 14 weeks following treatment (table 2). The barns were continually in use by the owners, housing livestock in all the stalls, and the lofts above the stalls were used for hay storage during the summer. The mosquito population in the area were lower in the posttreatment period than in the pretreatment period as is evidenced by the counts in the check barn and the untreated sides of the other barns; however, sufficient adult *A. quadrimaculatus* were present after treatment to make the differences between the treated and untreated portions of the barns highly significant (table 2). Only an occasional mosquito was found in the treated stalls during the remainder of the season. As late as the middle of September (11 weeks after treatment) there was a com-

TABLE 2.—*Average* A. quadrimaculatus *counts in treated and untreated barns*

	Barn 1		Barn 2		Barn 3 (check)	
	North	South	North	South	North	South
	Untreated	Treated	Untreated	Treated	Untreated	Untreated
Average weekly count before treatment[1] (4 inspections)	472±42	509±67	1,815±365	2,418±586	688±173	321±61
Average weekly count after treatment[1] (14 inspections)	123±25	0.2±0.2	181±27	0.2±0.1	184±42	140±31

[1] Plus or minus figures indicate standard errors of the mean.

plete absence of mosquitoes in the treated stalls although they were still abundant in the untreated stalls.

Experimental house tests.—To obtain detailed information on the residual effect of DDT sprays on adult *A. quadrimaculatus*, three unoccupied experimental houses, each having about 1,000 square feet of wall surface area, were mosquitoproofed. These houses were located in the Blackwell Swamp area of Wheeler Reservoir. This area was diked off from the main reservoir and relatively constant water levels were maintained throughout the season, resulting in a very heavy production of *A. quadrimaculatus*. Two of the houses had papered walls and ceilings, and one was wooden surfaced. On July 2, 1944, the wooden and one of the papered houses were sprayed with DDT emulsion (made from the xylene concentrate) at the rate of 250 mg. DDT per square foot, and the third house was left unsprayed to serve as a control. One of the treated houses and the control house were equipped with entrance and exit cones (fig. 2) so that mosquitoes entering or leaving the buildings could be trapped. A number of strategically placed nail kegs whose daily populations averaged from 200 to 1,000 *A. quadrimaculatus* adults provided abundant material for experiment. One or more of these kegs of mosquitoes were liberated in or near the houses for each test. Detailed observations were made in one of the DDT-treated houses (papered) at intervals during a 15-week period from July 4 until the middle of October when cold weather ended the mosquito breeding season. The results are summarized in table 3.

The house remained highly toxic to adult *A. quadrimaculatus* during the entire 105-day posttreatment period during which the observations were made. The time required for complete knockdown of the mosquitoes remaining in the building varied from 45 to 180 minutes. This variation appeared to be due to temperature changes and differences in the inherent susceptibility of the mosquitoes rather than to a progressive decrease in the toxicity of the DDT-treated surface.

Routine house-spraying tests.—During the summer of 1944, 3 blocks of dwellings, aggregating 67 houses, were treated with DDT.

TABLE 3.—*Effect of DDT-treated house on introduced* Anopheles quadrimaculatus *adults*

Date	Days after spraying	Time of day	Temperature (degrees F.)	Total number adults	Adults leaving house		Mortality of those leaving (knockdown)		Time for complete knockdown in house
					Percent	Time after entrance	Percent	Hours after leaving	
1944									*Minutes*
July 4	2	8:45 p. m.	80	629	88	15 minutes	100	3¼	120
July 6	4	1:30 p. m.	85	910	84	30 minutes	96	4	75
July 8	6	6:50 a. m.	71	1,584	60	65 minutes	85 99	4 24	70
July 12	10	12:15 p. m.	90	494	70	50 minutes	95	2	50
July 18	16	7 a. m.	96	3,000	64	30 minutes	100	24	90
July 20	18	12 m.	100	2,000			50 100	1 24	45
Aug. 3	31	11 a. m.	94	416	48	1¼ hours	100	24	80
Aug. 19	47	1:10 p. m.	93	540	50	3 hours	100	5	180
Aug. 30	58	12 m.	93	237	61	1¼ hours	100	5½	150
Sept. 6	65	1:35 p. m.	90	158	40	2 hours	90 100	3½ 19½	120
Sept. 27	86	11:15 a. m.	87	460	57	2 hours	98	5	120
Oct. 16	105	12:30 p. m.	79	176	28	2 hours	46 96	3 6	145

Two of these blocks were in the Blackwell Swamp area of Wheeler Reservoir and the other was in the Springville area of Kentucky Reservoir. The first block of houses in the Blackwell Swamp area (treated on July 4) was studied much more thoroughly than the others and will form the basis of this discussion. The statistics of DDT spraying in this area are given as follows:

Size of area	square miles (approximately)	2
Number of houses treated		21
Number of rooms treated		66
Average amount DDT stock per house	quarts	1. 4
Approximate rate of DDT application	milligrams	200 per square foot
Average time required per house:		*Minutes*
Spraying		14. 5
Other		12. 0
Total		26. 5

The stock solution consisted of 25 percent DDT, 7 percent Triton, and 68 percent xylene. For application, the stock solution was mixed 1 to 4 with water, giving a 5 percent DDT concentration in the finished spray. The spraying was done by a 2-man crew using a portable, hand-spray rig (fig. 3) which gave a wet spray suitable for impingement on walls and ceilings. This spraying equipment has been described in detail by Kiker and Sparkman (*1*). It is estimated that in a typical rural section of the Tennessee Valley 2 men with this equipment and a pick-up truck should be able to treat about 20 houses per day, with their total daily travel between houses averaging about 50 miles.

FIGURE 2.—Experimental houses in the Blackwell Swamp area of Wheeler Reservoir used for observing the effectiveness of DDT residual sprays. The house in the background was sprayed with DDT at the rate of 250 mg. per square foot, and the one in the foreground was left untreated to serve as a control. Screen entrance and exit cones and an exit trap are in place on the house in the foreground.

A. Application of DDT residual spray to the inside of a house. Pictures, clothing, etc., were not removed from the wall. A respirator was worn while applying the spray.

B. Application of DDT residual spray to the porch of a rural house.

FIGURE 3.—Application of DDT residual sprays.

No attempt was made to clear the walls and ceilings of pictures, garments, etc., as it was reasoned that mosquitoes would rest on these after the walls were sprayed. Furniture was pulled out from the walls in order to spray thoroughly the corners of the rooms. Food left in the open was covered with paper or cloth before spraying.

As the concentration of xylene in the emulsion mixture was some 12 times the maximum permissible concentration set by the American Standards Association for prolonged exposure, and as the toxicity of DDT under these conditions is unknown, the workers were equipped with respirators offering protection against organic vapors. It was determined, however, that the maximum concentration of xylene was considerably below the lower explosive limit; therefore, cooking fires were not extinguished before spraying.

Evaluation of the results of this treatment was difficult. Three methods could be used: (1) the numbers of *A. quadrimaculatus* found in the treated houses; (2) the release of adult mosquitoes in treated houses; and (3) information that could be derived from questioning the inhabitants of the residences. The first method could not be used to advantage since even before treatment the number of mosquitoes found in most of the houses during the day was extremely small even though night biting was severe. No adult *A. quadrimaculatus* were ever found resting in any of the houses following treatment although they were examined frequently during the remainder of the summer and early fall.

Release of mosquitoes in the occupied dwellings treated with DDT on July 4 showed that these houses remained toxic to *A. quadrimaculatus* adults for the remainder of the season. However, comparative studies indicated that the occupied houses lost their toxicity more rapidly than the uninhabited experimental houses. For example, the time required for complete knockdown of *A. quadrimaculatus* adults in the papered living room of an inhabited house 8 weeks after treatment was 230 minutes; a parallel test run in the unoccupied papered house gave a total knockdown time of only 150 minutes. The maximum time required for complete knockdown in the unoccupied house during the 15-week period after treatment was 180 minutes.

It was difficult to make an evaluation of the routine house spraying by means of the third method (questioning of inhabitants). The reaction of the people varied considerably, but it was quite evident that the mosquito situation had been improved for considerable periods of time in all the houses. About a week after treatment the houses were inspected and the residents interviewed. In almost all cases it was found that the mosquitoes were not staying in the houses or biting to any great extent. A typical comment was that the mosquitoes would enter the house in the evening, buzz around a while, and then leave without biting. An even more spectacular

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result of the treatment was the almost complete absence of houseflies. In houses which had been heavily infested before treatment there were practically no living flies to be found.

Two weeks after spraying, the situation was somewhat the same. The flies were still controlled completely, and there were only a few complaints that the mosquitoes were beginning to bother again.

Four weeks after treatment, the situation had changed noticeably. The sentiments of the inhabitants were about equally divided between those who thought that the mosquitoes were still under control and those who were convinced that the treatment was no longer effective. In all cases more mosquitoes were apparently entering the houses and staying for longer periods, and in many of the houses it was claimed that they were again biting as much as before treatment. However, it was stated by some that the mosquitoes were still not biting. It was interesting to note that without exception the flies were still being controlled in all sprayed houses.

Two weeks later (6 weeks after treatment) the houses were again inspected, but the situation was about the same as found in the previous inspection. A typical response of the inhabitants was that the mosquitoes were coming into the house in large numbers in the evening and were extremely bothersome for 30 to 40 minutes. They then quieted down and were not active for the rest of the night. In all cases the flies were still under control.

Another inspection on September 16, 1944, about 10 weeks after treatment, indicated that the mosquitoes were again about as bad as they were before treatment although the biting rates were still not as high and the biting did not continue as long through the night. The houseflies were still under control. One of the houses had been rebuilt and the walls repapered, and in this house numerous flies could be found while they were still absent from houses which had been treated. A general conclusion can be reached that the treatment with DDT remained fairly effective for at least 1 month and was effective to a lesser degree for another month at least.

Flaking tests.—It was noticed in the course of the summer's work that mosquitoes in cages not actually in contact with DDT-treated surfaces repeatedly suffered 100 percent mortality in 24 to 48 hours. This was not due to fumigational effect because mosquitoes placed in a container with a large amount of crystalline DDT, but prevented from coming into contact with it by screen, were not affected. Several experiments were conducted to determine if the mortality was caused by the flaking off of minute DDT crystals. On several occasions, 2 wire cages containing *A. quadrimaculatus* adults were suspended, 1 each in the DDT-treated house and the untreated control house. In one case 50 percent of the mosquitoes in the cages in the treated house were down after 12 hours, while none were down in the control. In

another case 98 percent were down after 12 hours in the treated house, while only 2 percent were down in the control. In another experiment, 10 mosquitoes were placed in each of 4 ice cream cartons with cheesecloth tops. One carton was placed in the center of a DDT-treated room, another in a corner, the third in the center but protected from falling DDT crystals by a piece of cardboard supported 2 inches above the top, and the fourth was placed in an untreated room to serve as a control. The results were as follows:

Time:	Percent knockdown			
	Center covered	*Center open*	*Corner open*	*Control*
24 hours	0	10	30	0
48 hours	20	100	100	0

Similar results were obtained by suspending caged mosquitoes in DDT-treated kegs. It therefore appears that the loss in toxicity of DDT-treated surfaces through aging is due principally to the flaking off of the DDT crystals rather than to volatilization. Accelerated flaking due to vibration may also be a reason for inhabited houses losing their toxicity more rapidly than uninhabited houses.

Relation of type of surface to residual toxicity.—As pointed out in the discussion of the board tests, smooth enameled surfaces treated with DDT lost their residual toxicity for *A. quadrimaculatus* adults much more rapidly than did rough wallboard. This suggested that the type of wall surface might be important in relation to the residual toxicity of DDT-treated houses. Accordingly, parallel observations were made in a house with papered rooms and one with rough wooden surfaces. As was observed in the board tests, the smooth papered surfaces lost their toxicity more rapidly than the rough wooden surfaces. For example, 8 weeks after treatment the time required for complete knockdown of *A. quadrimaculatus* adults in the papered house was 150 minutes, while in the wooden-surfaced house it was only 90 minutes. The difference was probably due to the more rapid flaking off of the DDT from the papered surfaces.

Similar results were obtained by suspending cages of adult *A. quadrimaculatus* in DDT-treated kegs with natural wooden surfaces and in kegs lined with smooth kraft paper. The rate of knockdown was usually greater in the papered kegs than in the unpapered kegs, indicating a more rapid flaking off of DDT from the papered surface than from the wooden surface.

REPELLENCY OF DDT-TREATED SURFACES

Preliminary observations indicated that DDT-treated surfaces might have a repellent as well as a toxic effect upon *A. quadrimaculatus* adults. Repellency studies were therefore carried out in DDT-treated kegs, barns, and houses.

Keg tests.—Information on the repellent effect of DDT was

obtained by comparative observations with treated and untreated nail kegs. During the early part of May a series of kegs was placed around the Blackwell Swamp area of Wheeler Reservoir in situations where they would serve as favorable diurnal resting places for adult *A. quadrimaculatus*. Large numbers of mosquitoes began using the kegs, and at 3 o'clock one afternoon over 2,000 *A. quadrimaculatus* adults were observed in one keg. This keg was removed and replaced by 3 kegs which had been treated on April 29 with an aqueous emulsion of DDT at the rate of about 200 mg. DDT per square foot. At 8 p. m. on the following day, the treated kegs were inspected and no mosquitoes were found in any of them, although untreated kegs in the same area contained large numbers of *A. quadrimaculatus* adults. Since no dead mosquitoes were found in the kegs, it was apparent that they had been repelled by the DDT. The next step was to determine whether the mosquitoes were repelled before they alighted upon the DDT-treated surface or if they were caused to leave by the irritation resulting from a period of resting upon it. Accordingly, a treated and an untreated keg were placed side by side and observed in the early morning hours. At 5 a. m. there were no mosquitoes in either keg, but at 5:15 a. m. (just at the break of dawn) mosquitoes started entering the kegs. They appeared to enter the treated as freely as the untreated keg, several hundred entering each keg in a 10-minute period. However, the mosquitoes which entered the treated keg began to show signs of agitation within about 5 minutes, and within 20 minutes all had left, most of them apparently flying into the untreated keg. It therefore appears that DDT acts as an irritant to *A. quadrimaculatus* adults and that the mosquitoes must actually rest upon the DDT-treated surface for a short period in order to be repelled by it.

In order to determine if the mosquitoes had received a lethal dose of DDT before leaving the treated keg, the experiment was repeated and after a large number of *A. quadrimaculatus* adults had entered the keg, a screen trap was placed over the opening to catch them as they emerged. The trapped mosquitoes were then observed for mortality, and within 48 hours all had died. This would indicate that *A. quadrimaculatus* adults which rest upon DDT-treated surfaces receive a lethal dose before they are sufficiently irritated to leave.

Barn tests.—The effectiveness of DDT residual sprays in keeping barns free of mosquitoes has been previously discussed (table 2). The almost complete absence of mosquitoes in the treated sides of the barns, while the populations of adults in the untreated sides and in the control barn remained high, is a definite indication of the repellent effect of DDT against *A. quadrimaculatus* adults. The mosquitoes apparently entered the treated and untreated sides of the barns in equal numbers in the early hours of the morning when seeking out a diurnal resting place, but left the treated side shortly there-

after. An inspection of the treated stalls in one barn before daylight revealed about 10 mosquitoes in the treated stalls and a few more in the untreated, but several hours later there were none to be found in the treated side, while a large number were resting in the untreated stalls. These data give additional support to the conclusion reached from the keg studies that *A. quadrimaculatus* will not rest on DDT-treated surfaces for any length of time if the structure is open and the insects are able to leave.

It was interesting to note that in addition to the absence of mosquitoes resting in the treated stalls there was also an almost complete absence of flies and other insects, although they abounded in the untreated stalls and barn.

Experimental house tests.—Observations on the repellent effect of DDT in the experimental houses during the first few days after treatment (250 mg. DDT per square foot) indicated that the DDT spray was rather effective in preventing the biting of *A. quadrimaculatus*. For example, on July 7 (5 days after treatment) one person spent the night in one of the DDT-treated houses with the door left open, while another remained in the control house nearby. Although many mosquitoes entered both buildings, only 4 bites were received by the person in the DDT-treated house, while a large number of bites were received by the person in the control house. Similar observations carried out on July 13 (11 days after treatment) indicated that the biting rate in the treated house had increased, as many as 5 bites being recorded in one 15-minute period. However, the treatment was still fairly effective in reducing the biting rate. An estimated 500 mosquitoes entered the building during a 15-minute period at the break of dawn (5 a. m. to 5:15 a. m.), but only a few of them took blood meals. By 6:45 a. m., all of the mosquitoes had escaped from the building except one engorged female which was dead upon the floor; in the untreated control house, large numbers of adults were resting in the normal manner.

On the night of July 25 (23 days after treatment), observations were made in the treated house with the door closed, the entrance cones open, and the exit traps in place. During the night, 72 adult *A. quadrimaculatus* entered the house and 17, or approximately 25 percent, of these took blood meals from the person occupying the house. On the following morning 9 of the 17 engorged females had escaped into the exit trap, and 3 of them were already dead; 8 of the females which took blood meals died before they escaped from the building. During the same night only 40 *A. quadrimaculatus* adults entered the control house in which an individual spent the night protected from bites by mosquito netting. These observations are in agreement with the results of the keg and barn tests and indicate that DDT residual sprays are not effective in preventing mosquitoes

from entering a building, but exert their repellent effect as irritants after the mosquitoes have been in contact with the DDT-treated surface for a short period.

The data which have been presented in table 3 give further information on the repellent effect of DDT residual sprays. It will be observed that the percent of mosquitoes escaping from the experimental house was highest (84 and 88 percent) during the first few days after treatment. This would indicate that DDT produces an irritant effect much more rapidly on freshly treated surfaces and thus causes a higher percentage of the mosquitoes to leave before being knocked down. This offers a logical explanation for the observed effectiveness of DDT residual sprays in preventing biting during the first week or two following application.

Although a major portion of the mosquitoes released in the experimental house during the first few days after treatment escaped to the outside, they had already received a lethal dose of DDT in their brief period of contact with the treated surfaces as is evidenced by the mortality records given in table 3. All of the mosquitoes which escaped into the window traps on the second day after treatment were dead within 3¼ hours. This high mortality of mosquitoes escaping from the treated building continued during the entire 105-day posttreatment period. Under comparable conditions, it is evident that at least 95 percent, and probably almost 100 percent, of the *A. quadrimaculatus* adults entering a DDT-treated building would receive a lethal dose before they could escape, although the percent mortality might be somewhat lower in more open structures. It therefore appears that most of the mosquitoes which might enter a DDT-treated building and feed upon a person with malaria would be killed before they could transmit malaria to another person, even though a considerable portion might escape from the building before dying. Thus, the use of DDT residual sprays should be an effective means of breaking the chain of malaria transmission between gametocyte and sporozoite formation.

Routine house-spraying tests.—As has been previously pointed out, it was difficult to evaluate the effectiveness of the routine house-spraying tests. However, some evidence of the repellent effect of the DDT sprays may be obtained from the comments of the occupants, which were summarized in the discussions on residual toxicity. From these comments it appears that the DDT sprays largely prevented mosquito biting for the first week or two after their application. Following this there was a gradual increase in the biting rate although there was some evidence of partial protection from biting for as long as 8 or 10 weeks after treatment. These general observations on the repellency of DDT residual sprays are in agreement with the results of the more detailed studies carried out in the experimental houses.

REACTION PATTERN OF MOSQUITOES TO DDT-TREATED SURFACES

During the course of the experimental house studies, some 10,000 *A. quadrimaculatus* adults were released in one of the sprayed houses, and their reactions to the DDT-treated surfaces were observed (table 3). Exit traps were kept on the windows to catch the mosquitoes which left the house. The pattern of reaction remained rather constant during the entire 15-week period of posttreatment observation and may be summarized as follows:

1. Within 5 minutes after release during the daytime, approximately 95 percent of the mosquitoes released are at rest on walls and ceiling in the darkest corners.
2. Fifteen to twenty minutes after release, this condition is completely reversed; 95 percent of the mosquitoes are to be found flying about the room seeking exit.
3. From 20 minutes to 1 hour after release, the mosquitoes remaining in the house become progressively more uncoordinated and fly aimlessly into the walls and floor, sounding like raindrops hitting a roof.
4. Within 45 to 180 minutes after release, all of the mosquitoes either leave the house or are knocked down on the floor.
5. Of the mosquitoes escaping the house, 95 to 100 percent die within 24 hours, the majority dying within 2 to 3 hours.

Mosquitoes released in the same manner in the control house quickly settled in the darkest corners and remained there throughout the day. It is thus evident that the irritant effect of DDT produces a complete reversal of the normal light reactions of *A. quadrimaculatus* adults.

USE OF DDT AS A LARVICIDE

BOAT DISTRIBUTION OF DDT

Boats have been used rather extensively by the Authority for applying anopheline larvicides in situations where it was not feasible to use airplanes. The standard larvicide has been a 9 to 1 mixture of kerosene and black oil, usually applied at rates of 25 to 40 gallons per acre. The solubility of DDT in kerosene and its high toxicity to anopheline larvae suggested its use in boat oiling operations as a means of reducing the amount of larvicide required. Accordingly, some tests were run with a 2.5-percent solution of DDT in kerosene, applied as a mechanical water emulsion with a modified boat oiling unit (*1*). The tests were run in the fall of 1944 in the Kentucky Reservoir, which was then undergoing its initial impoundage. Unusually high densities of *A. quadrimaculatus* prevailed in the experimental area, larval counts averaging from about 2 to 8 per square foot. In the first test the material was applied at a rate of approximately 0.6 gallon of the 2.5-percent solution per acre, which was equivalent to about 0.1 pound DDT per acre. This treatment gave a very satisfactory control, with the larval kill averaging 96 percent. In a second test, treatment was made at the rate of about 0.05 pound DDT per acre (0.3 gallon of 2.5-percent solution). At this rate, the control

was somewhat spotty, the larval kill ranging from 77 to 96 percent in different parts of the treatment area. It therefore appears that a dosage of about 0.1 pound DDT per acre is required for effective control of *A. quadrimaculatus* larvae when applied by this method. This rate of application would result in a decrease of about 98 percent in the amount of kerosene used and would thereby effect a considerable reduction in the cost of boat oiling operations.

AIRPLANE DISTRIBUTION OF DDT

Dusts.—During the summers of 1943 and 1944, a series of field tests was run to determine the feasibility of applying DDT dust larvicides by means of the Stearman airplanes, used by the Authority to distribute paris green for the control of *A. quadrimaculatus* (*2*). In the initial tests it was found that DDT powder, diluted with soapstone at the customary ratio of 1 to 4, produced a very sticky mixture which clogged in the plane hopper and fell in large chunks. With this material, rates of application as high as 2 pounds per acre were required for satisfactory control. Under reservoir conditions no residual toxicity to *A. quadrimaculatus* larvae was observed with this high rate of application. When the concentration of DDT was reduced to 10 percent, more satisfactory results were obtained, but even then the dust tended to pack in the hopper and did not discharge freely. It was found necessary to reduce the concentration of DDT to 5 percent before a satisfactory dusting mixture could be obtained. With this low concentration dust, 90 percent larval control was obtained over 200-foot swaths at actual application rates as low as 0.05 pound DDT per acre. The results of five airplane dusting tests are given in table 4.

TABLE 4.—*Effectiveness of DDT dusts applied by Stearman airplane for the control of* Anopheles quadrimaculatus *larvae, 1943—44*

DDT concentration (percent)	Discharge DDT (pounds per acre per 100-foot swath)	Plant cover	Number of larvae per square foot (before treatment)	Percent control	Swath width (feet)
25	1.9	Medium *Nelumbo* *Panicum* *Persicaria*	1.6	99 63	100 200
10	.9	Medium *Panicum* *Eleocharis* *Ammannia*	[1] 12.0	95 70	120 200
10	.9	Heavy *Saururus* *Panicum* *Peltandra* *Persicaria*	[1] 12.0	93 78	120 200
5	.1	Low *Persicaria*	6.2	100 85	150 250
5	.1	Medium *Persicaria* *Saururus*	2.0	98	180

[1] Larvae planted in floating wooden frames.

Although the 5-percent DDT dust gave very satisfactory results, its use was objectionable because the high percentage of inert diluent greatly decreased the pay load of the dusting plane. Attention was therefore shifted to the airplane distribution of liquid solutions of DDT.

Sprays.—Following the lead of the Orlando laboratories of the United States Bureau of Entomology and Plant Quarantine, the first DDT larvicidal sprays were applied as oil solutions distributed by a Cub airplane (Model J3 with 65-hp. Continental engine). The airplane was equipped with a spray unit developed by the Orlando group and loaned to the Authority for use in field experiments. Very satisfactory anopheline control was obtained with this unit when DDT was applied as a 5-percent solution in kerosene or as aqueous emulsions at rates of 0.1 to 0.25 pound per acre (table 5); however, the effective swath width was never in excess of 40 feet and the pay load was severely limited. In an attempt to improve these features, attention was turned toward the adaptation of the Authority's Stearman dusters for the distribution of larvicidal sprays. One of the reserve gasoline tanks located in the top wings was used to hold the DDT solutions. A small wind-driven oil pump attached to the landing gear superstructure supplied the necessary pressure, and the spray was discharged through seven whirl-disc nozzles located on the trailing edges of the lower wings (fig. 4A). This unit proved to be more satisfactory than the Cub unit, having a much higher pay load and a greatly increased swath width. It soon became apparent, however, that for airplane

TABLE 5.—*Effectiveness of DDT sprays applied by Cub and Stearman airplanes for the control of* Anopheles quadrimaculatus *larvae, 1944*

Material	Plane	Equipment	Discharge DDT (pounds per acre)	Swath width (feet)	Plant cover	Number of larvae per square foot (before treatment)	Percent control	Swath width
5 percent DDT in kerosene.	Cub	6 whirl disk nozzles (0.067" orifice) in venturi throat.	0.26	40	Low *Aster* *Persicaria* *Panicum*	3.3	97	Routine. 40 feet.
5 percent DDT in kerosene.	do	do	.12	40	Medium *Echinodcrus*	1.4	100	Routine. 40 feet.
5 percent DDT aqueous emulsion.[1]	do	do	.10	40	Low *Tecoma* *Juncus* *Panicum*	.56	100	Routine. 40 feet.
20 percent DDT in Velsicol NR-70.	Stearman	7 whirl disk nozzles (0.0465" orifice) along lower wings.	.08	100	Medium-high *Saururus* *Nelumbo*	1.9	100 87	120 feet. 350 feet.
15 percent DDT emulsion.[2]	do	do	.06	100	Heavy *Saururus*	2.0	100	200 feet.

[1] Made from stock solution consisting of 25 percent DDT, 68 percent xylene, and 7 percent Triton (emulsifier).

[2] Made from stock solution of 30 percent DDT in Velsicol NR-70 mixed in equal parts with water and emulsified with Vatsol.

distribution a solvent was needed which would dissolve a large amount of DDT yet would have a high boiling point and be of low viscosity. Certain polymethylnaphthalenes [3] were found to meet these requirements. Fifteen- to forty-percent solutions of DDT in this material gave adequate larval control over 200- to 300-foot swaths when applied with the Stearman unit. Larval kills of 90 percent or better were obtained at actual treatment rates of less than 0.03 pound of DDT per acre. The spray consisted of droplets from 100 to 500 microns in diameter which at the rates of application used did not form a complete surface film. Effective results were also obtained when these solutions were applied in the form of water emulsions.

One objection to the airplane sprays was the fact that they were almost invisible. The high visibility of the regular paris green-soapstone dust cloud aids the pilot in gauging swath widths and determining the distribution of the larvicide.

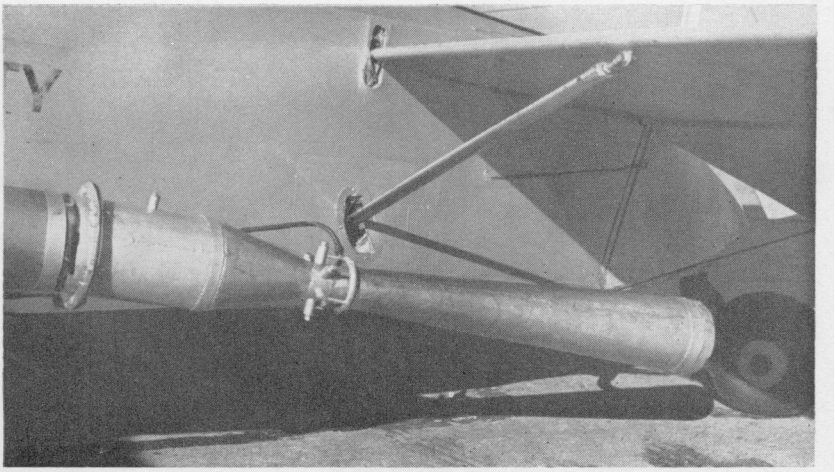
Table 5 presents the data obtained from a series of field tests on the airplane distribution of larvicidal sprays.

Thermal aerosols.—In an effort to obtain a finer breakup of the DDT solutions than could be obtained with airplane spraying equipment, attention was turned toward the use of exhaust generators to produce thermal aerosols. The Orlando laboratories had reported successful results with an exhaust generator fitted to a Cub airplane, and it was decided to equip in a similar manner one of the Authority's Stearman dusting ships. The first unit consisted of a pipe 4 inches in diameter extending 22 feet from the exhaust manifold to the rear of the plane. Solutions of DDT in Velsicol were injected into the pipe through various types of nozzles. The temperature of the exhaust gases in the pipe was about 1,100° F. with a mean velocity of about 235 feet per second. Using a 20-percent solution of DDT in Velsicol NR-70 discharged downstream through a ⅛-inch jet at the center of the pipe, the generator produced a fine aerosol spray in which most of the particles were between 15 and 60 microns in diameter. However, a sufficient amount of smoke (less than 1 micron in diameter) was produced to make the aerosol cloud quite visible (fig. 5).

DDT thermal arerosols distributed with the 4-inch exhaust generator gave very satisfactory control of anopheline larvae, 90-percent kill being obtained at actual treatment rates as low as 0.03 pound DDT per acre (table 6), but it produced an objectionable back pressure on the airplane engine. The 4-inch pipe was therefore replaced by a 6-inch pipe. The temperature of the exhaust gases in this generator was about 1,000° F. with a mean velocity of about 105 feet per second. With the 20-percent solution of DDT in Velsicol, the 6-inch generator produced either a pure smoke or smoke and coarse spray, depending on the position of the nozzle in the pipe. DDT thermal aerosols

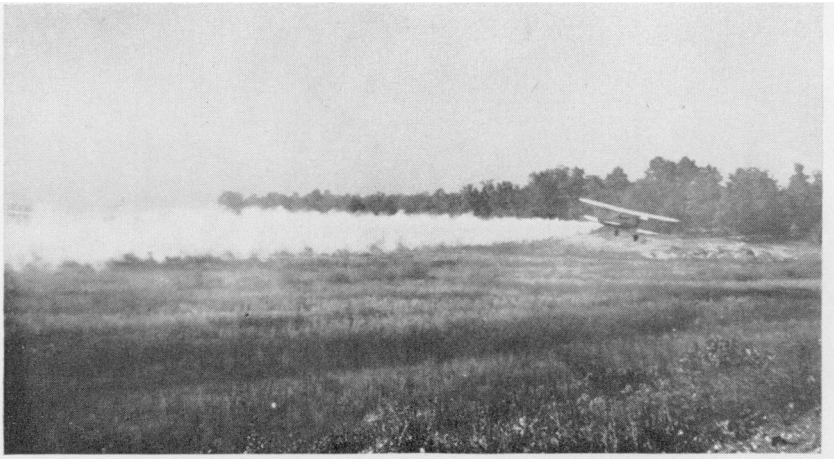
[3] Manufactured by the Velsicol Corporation, Chicago, Ill.

A. View of airplane showing the 6″ exhaust generator equipped with venturi for distributing thermal aerosols. Note also the nozzles along the trailing edge of the lower wing for distributing oil sprays.



B. Close-up of the venturi section of the exhaust generator. The venturi has an inside throat diameter of 2⅜ inches.

FIGURE 4.—Stearman dusting plane equipped for distributing DDT sprays and thermal aerosols.



A. View of aerosol cloud immediately after being discharged from the airplane.

B. View of the aerosol cloud a few seconds later, showing how it settles to the water surface. Note also the swirling action of the finer parts of the cloud as it reaches the water surface.

FIGURE 5.—Stearman airplane equipped with venturi exhaust generator distributing DDT thermal aerosol.

TABLE 6.—*Effectiveness of DDT thermal aerosols distributed by airplane for the control of* Anopheles quadrimaculatus *larvae, 1944*

Material	Plane equipment	Discharge DDT (lbs. per acre per 100-foot swath)	Plant cover	Number of larvae per square foot (before treatment)	Percent control	Swath width
20 percent DDT in Velsicol AR-50	4" exhaust generator	0.1	Low *Tecoma* *Aster*	1.6	100	Routine 50 feet.
1 part 15 percent DDT in Velsicol AR-50 to 3 parts fuel oil.	do	.1	Medium-high *Nelumbo*	1.3	88	Routine 50 feet.
Do	do	.1	Low *Persicaria*	2.3	100 92	100 feet. 350 feet.
Do	6" exhaust generator	.1	Low-medium *Tecoma* *Aster*	3.1	100	200 feet.
20 percent DDT in Velsicol AR-50	do	.08	Low *Persicaria*	2.7	100 84	180 feet. 300 feet.
20 percent DDT in Velsicol NR-70	do	.08	High *Nelumbo*	1.4	94	Routine. 100 feet.
20 percent DDT in Velsicol NR-70	do	.08	Medium-high *Nelumbo* *Saururus*	2.7	100 94	60 feet. 200 feet.
15 percent DDT emulsion [1]	do	.25	Medium-high *Saururus*	4.3	100	Routine. 50 feet.
15 percent DDT emulsion [1]	do	.14	Medium-high *Saururus*	3.1	100	Routine. 100 feet.
20 percent DDT in Velsicol NR-70	6" generator with 2⅜ venturi	.12	Low *Aster*	4.7	96 82	150 feet. 350 feet.
20 percent DDT in Velsicol NR-70	do	.12	Heavy Woods, 100-feet trees	2.2	100	Routine. 100 feet.
20 percent DDT in Velsicol NR-70	do	.12	Medium-heavy *Ambrosia* *Andropogon*	4.9	99	250 feet.
20 percent DDT in Velsicol NR-70	do	.12	Medium-heavy *Ambrosia* *Andropogon*	10.5	99.7	Routine. 100 feet.

[1] Made from stock solution of 30 percent DDT in Velsicol NR-70 mixed in equal parts with water and emulsified with 2 percent Vatsol.

applied with the 6-inch generator gave very effective control of anopheline larvae (table 6), but in general it was not as satisfactory as the 4-inch generator.

In order to retain the low back pressure characteristics of the 6-inch generator and yet produce an aerosol with a higher prcentage of droplets with diameters in the 5- to 25-micron range, a venturi section was fitted to the end of the 6-inch pipe (fig. 4). This venturi was developed by the staff of the National Defense Research Committee Munitions Development Laboratory of the University of Illinois who cooperated with the Authority's staff in adapting it for use on the Stearman dusters and comparing its effectiveness with the straight exhaust generators. A report of these cooperative studies, including a detailed description of the venturi, has recently been submitted by LeTourneau et al. (*3*).

Two sizes of venturis were used: (1) a 2.38-inch throat giving a gas velocity of about 660 feet per second, and (2) a 1.9-inch throat giving a velocity of about 931 feet per second. The smaller venturi gave an unsatisfactory spray and developed too much back pressure; the larger venturi (2⅜-inch throat) was therefore adopted for use in more extensive tests. Using 20 percent DDT in Velsicol discharged through six 1/16-inch jets, this generator produced an aerosol in which over 90 percent (by weight) of the droplets were between 5 and 100 microns in diameter and some 40 percent were between 5 and 50 microns in diameter. A small percentage of the material was in the size range of smoke particles so that the aerosol cloud was quite visible as it was discharged from the plane (fig. 5A). The aerosol was rapidly carried to the water surface by the down draft of the plane and penetrated vegetation very effectively (fig. 5B). Larval kills of 90 percent or better were obtained with this unit over swaths as wide as 300 feet at actual application rates as low as 0.04 pound DDT per acre. The results of four field tests with the venturi generator are given in table 6.

USE OF DDT AS AN ADULTICIDE

While conducting larvicidal experiments with DDT thermal aerosols attention was also given to the use of these materials as mosquito adulticides since promising results along this line had been reported by the Orlando laboratories and the Office of Scientific Research and Development groups from the University of Illinois and Columbia University. A series of field tests was run with the Stearman unit to determine the practicability of distributing DDT thermal aerosols by airplane for the control of *A. quadrimaculatus* adults. The criteria of effectiveness were mortality records of mosquitoes caged in the treatment areas and observations of adult *A. quadrimaculatus* in kegs, tree holes, and other natural resting places. The results of a series of these field tests are given in table 7. The data indicate that neither

TABLE 7.—*Effectiveness of DDT thermal aerosols distributed by airplane for the control of* Anopheles quadrimaculatus *adults, 1944* [1]

Description of generator	Material	Characteristics of aerosol	Approximate dosage (pounds DDT per acre)	Type of area	Control of adult *A. quadrimaculatus*	
					Kill in cages after 24 hours (percent)	Control in natural resting places
4-inch pipe; ⅛-inch unbaffled jet, 4 feet from manifold.	20 percent DDT in Velsicol NR-70.	Smoke and spray to 100 microns. Many 5- to 50-micron droplets.	0.15	Open	90 to 100	90- to 100-percent kill in 24 hours in covered kegs.
Do	do	do	.08	High dense woods	20 to 80	Natural population reduced 90 to 100 percent. None dead in covered kegs.
6-inch pipe; 5/32-inch baffled jet, 11 inches from manifold.	30 percent DDT in Velsicol NR-70.	Pure screening smoke	.85	do	None	No reduction in natural populations.
6-inch pipe; 5/32-inch baffled jet, 4 feet from manifold.	15 percent DDT emulsion.[2]	Smoke and fine to coarse spray.	.55	do	80 to 100	Natural population reduced 65 to 100 percent.
Do	do	do	.4	Very dense woods; trees 100 feet.	99	Natural population reduced 97 percent.
6-inch pipe with 2⅜-inch venturi; six 1/16-inch jets.	20 percent DDT in Velsicol NR-70.	50 percent of droplets 5- to 50-micron diameter.	0.4 to .5	Dense woods; trees 100 feet high.	80 to 100	Natural population reduced to zero.

[1] Modified from Le Tourneau et al., 1944.
[2] Made from stock solution of 30-percent DDT in Velsicol NR-70 mixed in equal parts and emulsified with 2-percent Vatsol.

coarse sprays nor fine screening smokes were as effective as the fine-spray aerosols in which a large percentage of the droplets was in the 5- to 50-micron range. This is in agreement with observations of Professor V. K. LaMer which show that the optimum droplet size for killing *Aedes aegypti* adults is with diameters of 10 to 15 microns (*3*).

The 6-inch exhaust generator with 2⅝-inch venturi appeared to be particularly satisfactory for the distribution of DDT thermal aerosols to control *A. quadrimaculatus* adults. This unit did not produce an objectionable back pressure as did the simple 4-inch generator and was highly effective in larvicidal as well as adulticidal operations. DDT applied in this manner at dosages of about one-half pound per acre appeared to give effective control of adult *A. quadrimaculatus* in their diurnal resting places. Excellent control of pest mosquitoes (*Aedes* and *Psorophora*) and other biting flies (*Chrysops* and *Tabanus*) was also obtained at this rate of application.

TOXICITY OF DDT TO FISH AND FISH FOOD ORGANISMS

One of the primary considerations involved in the introduction of a new mosquito larvicide is its effect upon other forms of wildlife, particularly fish and fish food organisms. With this in mind, some preliminary observations were made on the effect of DDT on wildlife. DDT dusts applied at rates of 0.1 pound DDT per acre gave no indication of injury to aquatic organisms other than mosquitoes, but 5-percent solutions of DDT in kerosene applied as sprays at rates of 0.1 to 0.25 pound DDT per acre were quite destructive to populations of aquatic insects living in close contact with the water surface, particularly Hemiptera and Coleoptera. Water boatmen (Corixidae) were especially susceptible to the DDT-oil sprays. Actual dipping records showed, however, that 20-percent solutions of DDT in Velsicol applied as thermal aerosols at rates of about 0.12 pound DDT per acre gave very efficient anopheline control without significant reduction of other aquatic organisms, such as mayfly larvae, midge larvae, beetle larvae, and water fleas (Cladocera).

SUMMARY AND CONCLUSIONS

Laboratory and field studies were conducted in the Tennessee Valley during 1943 and 1944 to provide information on the use of DDT as a residual house spray for the control of adult *A. quadrimaculatus* and on its effectiveness as an anopheline larvicide and adulticide when applied as a dust, a spray, or a thermal aerosol. The results of these investigations may be summarized briefly as follows:

1. Spray chamber tests indicated that the median lethal doses of DDT for adult *A. quadrimaculatus* males and females are about 7.0 and 12.0 mg. per 1,000 cubic feet, respectively, as compared with 1.0 and 1.5 mg. of pyrethrins.

2. Laboratory observations of wall board sprayed at rates of 40, 200, and 1,000 mg. of DDT per square foot showed that there was no significant difference in the initial toxicity to adult *A. quadrimaculatus* at the different dosages, the percent mortality being determined primarily by the period of contact. Residual toxicity, however, was dependent upon the rate of application, though not directly proportional to it; sufficient residual toxicity to produce 100 percent mortality to adults exposed for 60 minutes persisted for 4 to 16 weeks, depending on the dosage.

3. Wooden nail kegs treated with DDT at rates of 20, 200, and 2,000 mg. DDT per square foot retained a high residual toxicity to adult *A. quadrimaculatus* for 18 to 22 weeks; the exposure time required for a 100 percent knockdown during the first 18 weeks varied from about 1 to 6 hours, depending upon the dosage and the age of the treated surface.

4. Barns treated with DDT at a rate of about 200 mg. DDT per square foot remained almost entirely free of flies and mosquitoes for at least 11 weeks.

5. Unoccupied experimental houses treated with DDT at a rate of about 250 mg. DDT per square foot remained toxic to *A. quadrimaculatus* adults for at least 15 weeks; occupied dwellings lost their toxicity more rapidly than unoccupied houses but remained toxic to *A. quadrimaculatus* for at least 3 months.

6. The loss of residual toxicity by a DDT-treated surface appeared to be due primarily to the flaking off of DDT crystals. Smooth enameled or papered surfaces lost their toxicity more rapidly than rough wooden surfaces.

7. Observations in kegs, barns, and houses indicated that a DDT-treated surface exerts its repellent action as an irritant after the mosquitoes have been in actual contact with it for a short period; DDT residual sprays did not keep *A. quadrimaculatus* adults from entering houses, but they did prevent biting for a week or two and gave partial protection for as long as 8 or 10 weeks. Ninety-five to one hundred percent of the mosquitoes which escaped from a treated house had received a lethal dose of DDT before they left.

8. The pattern of reaction of *A. quadrimaculatus* adults to DDT-treated surfaces remained rather constant over a period of 15 weeks following treatment. Exposure to DDT surfaces completely reversed the normal light reactions of the mosquitoes, making them positively phototropic.

9. Solutions of 2.5 percent DDT in kerosene gave effective control of anopheline larvae when applied by boat oiling units at rates of approximately 0.1 pound DDT per acre, thereby making possible a reduction of about 98 percent in the amount of kerosene normally used.

10. DDT had to be diluted with 95 percent soapstone before a satisfactory airplane dusting mixture was obtained. With this mixture 90 percent control of *A. quadrimaculatus* larvae was obtained over 200-foot swaths at actual treatment rates as low as 0.05 pound per acre.

11. Certain polymethylnaphthalenes (Velsicols) having a high solubility for DDT and a high boiling point were found to be ideal solvents for making liquid solutions of DDT to be applied by airplane.

12. Stearman airplanes proved to be more satisfactory for applying DDT larvicidal sprays than Cub airplanes because of their greater pay load and increased swath width. Fifteen- to twenty-percent solutions of DDT in Velsicol applied with the Stearman unit at actual treatment rates as low as 0.03 pound DDT per acre gave at least a 90-percent kill of *A. quadrimaculatus* larvae over swath widths of 200 to 300 feet.

13. A Stearman airplane was equipped with various types of exhaust generators for producing thermal aerosols from concentrated solutions of DDT in Velsicol. The most satisfactory was one having a terminal venturi section with a 2⅝-inch throat. Thermal aerosols distributed with this unit at actual treatment rates as low as 0.04 pound DDT per acre gave at least 90-percent kills of anopheline

larvae over swaths as wide as 300 feet. Excellent control of *A. quadrimaculatus* adults in their diurnal resting places was also obtained with this unit at application rates of about 0.5 pound DDT per acre.

14. DDT dusts and thermal aerosols gave no evidence of injury to fish or other aquatic organisms when applied by airplane at rates of 0.1 pound DDT per acre. Five-percent solutions of DDT in kerosene applied at rates of about 0.25 pound DDT per acre were quite destructive to aquatic insects living in close contact with the water surface, particularly Hemiptera and Coleoptera.

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The writers wish to express their sincere thanks and appreciation to the many persons and agencies who have given advice and assistance in carrying out these studies.

Mr. E. F. Knipling and his staff at the Orlando laboratory of the United States Department of Agriculture deserve especial mention. It was through their suggestion that the Authority first initiated studies on DDT in the summer of 1943, and their continued cooperation and helpful advice have played an important part in the advancement of the DDT research program.

Other agencies which have provided assistance and information during the course of the studies include the National Defense Research Committee groups at the University of Illinois and at Columbia University; the Office of the Surgeon General of the United States Army; and the Office of Malaria Control in War Areas of the United States Public Health Service.

The following employees of the Tennessee Valley Authority deserve particular mention for their part in the studies: Dr. E. L. Bishop, for his enthusiastic support and coordination of the entire program; Mr. C. C. Kiker, Mr. C. W. Krusé, and Mr. Robert Sparkman, for developing special equipment and assisting with the engineering phases; Mr. Harold Seaton, for designing airplane equipment and piloting the experimental airplane; Miss Caroline Wilson, for technical assistance in the laboratory; Mr. Robert Crowell, for assistance in planning and carrying out the mosquito inspection service; and Mr. T. F. Hall and Mr. George G. Keener, for assisting in the collection of field data.

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COMMISSIONED CORPS OF PUBLIC HEALTH SERVICE TO BE BRANCH OF ARMED FORCES

The commissioned corps of the United States Public Health Service will become a branch of the land and naval forces of the United States under an executive order signed by President Truman on June 21. The order will be effective July 29 for the duration of the war.

Administration of the Public Health Service is not affected by the executive order. The Service continues to operate as a part of the Federal Security Agency. Public Health Service officers will be subject to the Articles for the Government of the Navy, with authority conferred by the Articles and by law on the Secretary of the Navy and the Commander of a fleet vested in the Federal Security Administrator and the Surgeon General of the Public Health Service. Officers of the Public Health Service on detail to the Army and Navy, however, will continue to be governed by the laws of the service to which they are assigned.

Under the executive order, commissioned officers of the Service will be subject to the same discipline and obligations and will have the same status as members of the Army, the Navy, and the Coast Guard. Their postwar status will be the same as that of all other veterans. The order also establishes uniformity in discipline and benefits among Public Health Service commissioned personnel. Up to the present, commissioned officers detailed to the Army, Navy, and Coast Guard, and all officers serving overseas have received full military benefits under the Public Health Service Act of 1944. The remainder of the corps has been entitled to only limited benefits. As a result, detail has determined the military status of Public Health Service officers, although the officers have no control over their detail, but perform the duties assigned them.

The commissioned corps totals 3,175, and is made up of physicians, dentists, sanitary engineers, pharmacists, scientists, and nurses. A large number of medical officers are engaged in direct care for the military forces. Practically all members of the corps are assigned to duties which have arisen directly out of the war effort. There is no enlisted personnel in the Public Health Service.

Since 1902, the President of the United States has been authorized by Congress to call upon the Public Health Service for direct military duty in time of threatened or actual war. In World War I, officers of the Service were made a part of the military forces by executive order. This action resulted from the realization that the close relationship between the Service and the military forces is not limited to individual officers detailed to the armed services, but extends to the Public Health Service as a whole.

The Public Health Service operates the medical services of the

Coast Guard in times of peace and war. The relationship of this service to the personnel of the Coast Guard is identical to the medical service supplied by the Bureau of Medicine and Surgery of the Navy to Navy personnel.

The text of the Executive Order of June 21, 1945, follows:

EXECUTIVE ORDER

DECLARING THE CNMMISSIONED CORPS OF THE PUBLIC HEALTH SERVICE TO BE A MILITARY SERVICE AND PRESCRIBING REGULATIONS THEREFOR

By virtue of the authority vested in me by section 216 of the Public Health Service Act, approved July 1, 1944, 58 Stat. 691; Title I of the First War Powers Act, approved December 1, 1941, 55 Stat. 838; and as President of the United States and Commander in Chief, I hereby declare the commissioned corps of the Public Health Service to be a military service and a branch of the land and naval forces of the United States during the period of the present war. The commissioned corps of the Public Health Service during such period shall be subject to the Articles for the Government of the Navy to the extent prescribed in the following regulations:

1. The Articles for the Government of the Navy are hereby adapted to apply to officers of the commissioned corps of the Public Health Service in the same manner and to the same extent as they apply to commissioned officers of the Navy under like circumstances.

2. Any member of the commissioned corps of the Public Health Service who violates any provision of the Articles for the Government of the Navy shall be subject to trial and punishment as prescribed therein. The authority conferred by the Articles for the Government of the Navy upon the Secretary of the Navy with respect to the convening of general courts-martial and courts of inquiry, the review of their proceedings and the confirmation, remission, mitigation, and execution of sentences of general courts-martial shall be vested in the Federal Security Administrator, and the authority conferred by law for such purposes upon the commander in chief of a fleet or squadron and other officers of the Navy shall be vested in the Surgeon General of the Public Health Service. The authority to convene a general court-martial or court of inquiry may not be delegated to any other officer of the Public Health Service.

3. The general courts-martial and courts of inquiry convened pursuant to this authority shall have the same powers and authority as other general courts-martial and courts of inquiry under the Articles for the Government of the Navy. The provision of Article 7 thereof shall apply in carrying out sentences of imprisonment and hard labor.

4. Commissioned officers of the Public Health Service now or hereafter detailed for duty with the Army, Navy, or Coast Guard shall be subject to the laws for the government of the service to which detailed as now prescribed by law. In the initiation, prosecution, and completion of disciplinary action, including remission or mitigation of punishments for any offense which has been or may be committed by any commissioned officer of the Public Health Service while detailed for duty with the Army, Navy, or Coast Guard, the jurisdiction shall depend upon and be in accordance with the laws and regulations applicable to the Army, Navy, Coast Guard, or Public Health Service, as the case may be, whichever has jurisdiction of the person of the offender at the various stages of such action: *Provided*, That any punishment imposed and executed in accordance with the provisions

of this paragraph shall not exceed that to which the offender was liable at the time of the commission of the offense.

5. Naval Courts and Boards, 1937 and modifications or revisions thereof, shall govern the conduct of general courts-martial and courts of inquiry in the Public Health Service.

6. This order shall be published in the Federal Register and shall be effective on and after the thirtieth day following the date of such publication.

THE WHITE HOUSE, *June 21, 1945.*

DEATHS DURING WEEK ENDED JUNE 9, 1945

[From the Weekly Mortality Index, issued by the Bureau of the Census, Department of Commerce]

	Week ended June 9, 1945	Corresponding week, 1944
Data for 93 large cities of the United States:		
Total deaths	8,900	8,360
Average for 3 prior years	8,588	
Total deaths, first 23 weeks of year	216,604	222,122
Deaths under 1 year of age	577	618
Average for 3 prior years	605	
Deaths under 1 year of age, first 23 weeks of year	14,174	14,396
Data from industrial insurance companies:		
Policies in force	67,354,290	66,602,953
Number of death claims	13,195	11,147
Death claims per 1,000 policies in force, annual rate	10.2	8.8
Death claims per 1,000 policies, first 23 weeks of year, annual rate	10.9	10.7

PREVALENCE OF DISEASE

No health department, State or local, can effectively prevent or control disease without knowledge of when, where, and under what conditions cases are occurring

UNITED STATES

REPORTS FROM STATES FOR WEEK ENDED JUNE 16, 1945

Summary

Only a slight increase occurred during the week in the incidence of poliomyelitis. A total of 96 cases was reported, as compared with 92 last week and a 5-year (1940–44) median of 42. Only 4 States reported more than 5 cases each (last week's figures in parentheses)—Texas 37 (42), New York 10 (11), Alabama 8 (2), and South Carolina 7 (3). Of the total of 999 cases reported to date, as compared with 657 for the same period last year and a 5-year median of 646, 198 were reported in Texas, 175 in New York, and 77 in California. Of the total of 602 cases reported during the 13-week period since March 17, the week of lowest reported incidence this year, 182 occurred in Texas, 78 in New York, and 41 in California.

A total of 133 cases of meningococcus meningitis was reported currently as compared with 143 for last week, 246 for the corresponding week last year, and a 5-year median of 64. Only 2 States reported more than 7 cases each (last week's figures in parentheses)—New York 18 (21), and Illinois 14 (10). The total to date this year is 5,151, as compared with 11,443 and 11,431, respectively, for the corresponding periods of the epidemic years of 1944 and 1943. The median number for the corresponding periods of the past 5 years is 1,855.

Cumulative totals for certain other diseases for the first 24 weeks of the year (figures for the corresponding period of last year in parentheses) are as follows: *Totals above last year's figures*—Diphtheria 6,347 (5,251), dysentery (all forms) 13,996 (10,229), leprosy 19 (15), Rocky Mountain spotted fever 113 (110), tularemia 376 (268), endemic typhus fever 1,364 (1,198), undulant fever 2,177 (1,484), whooping cough 60,055 (43,418). *Totals lower than last year's figures*—Anthrax 18 (19), infectious encephalitis 166 (265), influenza 65,147 (334,511), measles 83,539 (562,959), scarlet fever 123,662 (138,084), smallpox 235 (259), typhoid and paratyphoid fever 1,507 (1,900).

Deaths recorded during the week in 92 large cities of the United States aggregated 8,807, as compared with 8,852 last week, 8,267 for the corresponding week last year, and 8,152 for the 3-year (1942–44) average. The total for the year to date is 224,692, as compared with 229,646 for the same period last year.

Telegraphic morbidity reports from State health officers for the week ended June 16, 1945, and comparison with corresponding week of 1944 and 5-year median

In these tables a zero indicates a definite report, while leaders imply that, although none was reported, cases may have occurred.

Division and State	Diphtheria			Influenza			Measles			Meningitis, meningococcus		
	Week ended—		Median 1940–44	Week ended—		Median 1940–44	Week ended—		Median 1940–44	Week ended—		Median 1940–44
	June 16, 1945	June 17, 1944		June 16, 1945	June 17, 1944		June 16. 1945	June 17, 1944		June 16, 1945	June 17, 1944	
NEW ENGLAND												
Maine	0	0	1	------	------	1	0	320	182	0	0	0
New Hampshire	0	0	0	------	------	------	0	10	10	0	0	0
Vermont	1	0	0	------	------	------	49	28	74	0	0	0
Massachusetts	3	1	2	------	------	------	359	686	1038	6	7	5
Rhode Island	1	0	0	26	14	------	7	14	130	0	2	1
Connecticut	0	0	0	2	2	1	99	296	246	1	4	1
MIDDLE ATLANTIC												
New York	19	7	13	[1] 1	[1] 3	[1] 1	200	1,028	1,028	18	23	11
New Jersey	3	2	2	1	------	3	73	547	1,267	5	11	6
Pennsylvania	5	5	11	1	1	------	562	365	496	6	19	4
EAST NORTH CENTRAL												
Ohio	7	4	3	9	11	11	90	318	318	5	14	3
Indiana	5	2	2	2	4	4	12	35	58	3	5	2
Illinois	5	6	16	1	2	5	352	190	223	14	15	3
Michigan [2]	15	5	3	3	------	1	213	258	793	6	11	1
Wisconsin	2	2	1	6	5	13	66	1,136	1,136	4	3	0
WEST NORTH CENTRAL												
Minnesota	1	3	1	------	------	1	11	146	146	3	4	0
Iowa	4	3	2	------	------	------	55	64	130	3	0	0
Missouri	6	2	2	3	1	1	34	42	67	5	11	3
North Dakota	3	0	1	------	------	------	2	2	17	0	0	0
South Dakota	0	0	0	------	------	------	6	16	16	0	1	0
Nebraska	2	0	0	1	2	------	13	25	25	0	0	0
Kansas	8	1	1	9	1	1	65	90	165	6	4	1
SOUTH ATLANTIC												
Delaware	1	0	0	------	------	------	1	1	4	0	0	0
Maryland [2]	15	3	3	2	9	1	25	78	116	2	6	6
District of Columbia	0	0	0	------	1	------	2	149	74	1	1	0
Virginia	4	6	5	41	22	34	16	190	156	7	3	3
West Virginia	3	2	2	3	3	3	17	88	32	2	2	0
North Carolina	6	5	5	------	3	------	26	365	251	5	8	2
South Carolina	3	1	6	112	97	105	17	165	74	1	4	0
Georgia	4	4	3	------	2	4	5	26	43	1	0	1
Florida	1	3	2	------	3	3	12	56	56	1	8	1
EAST SOUTH CENTRAL												
Kentucky	2	1	2	------	32	2	67	53	56	2	4	1
Tennessee	2	0	1	13	16	16	30	45	79	6	10	1
Alabama	3	0	1	10	4	14	7	45	45	0	5	1
Mississippi [2]	8	1	1	------	------	------	------	------	------	3	0	0
WEST SOUTH CENTRAL												
Arkansas	2	1	3	3	17	6	39	65	46	0	1	0
Louisiana	6	2	2	2	2	4	9	48	19	2	5	2
Oklahoma	6	0	2	2	32	13	11	113	45	2	2	1
Texas	31	28	21	336	203	203	320	739	489	3	8	4
MOUNTAIN												
Montana	2	1	1	6	------	------	4	38	50	1	0	0
Idaho	0	0	0	------	------	------	1	5	12	0	0	0
Wyoming	0	0	0	------	------	1	4	31	34	0	0	0
Colorado	3	6	8	42	3	14	4	87	94	1	2	0
New Mexico	3	2	2	3	1	------	11	44	44	0	0	0
Arizona	12	0	1	25	26	38	16	30	38	0	1	1
Utah [2]	0	0	0	------	------	------	136	41	79	0	0	0
Nevada	0	8	0	------	------	------	1	71	10	0	1	0
PACIFIC												
Washington	5	8	2	1	1	1	99	220	187	1	7	1
Oregon	2	3	2	2	6	6	57	79	85	1	2	0
California	20	25	16	20	15	40	1,075	2,729	809	6	32	3
Total	234	153	154	688	544	630	4,280	11,217	12,480	133	246	64
24 weeks	6,349	5,251	6,051	65,147	334,511	165,861	83,539	562,959	485,042	5,151	11,443	1,855

[1] New York City only.
[2] Period ended earlier than Saturday.

Telegraphic morbidity reports from State health officers for the week ended June 16, 1945, and comparison with corresponding week of 1944 and 5-year median—Con.

Division and State	Poliomyelitis			Scarlet fever			Smallpox			Typhoid and paratyphoid fever [2]		
	Week ended—		Median 1940–44	Week ended—		Median 1940–44	Week ended—		Median 1940–44	Week ended—		Median 1940–44
	June 16, 1945	June 17, 1944		June 16, 1945	June 17, 1944		June 16, 1945	June 17, 1944		June 16, 1945	June 17, 1944	
NEW ENGLAND												
Maine	0	0	0	30	18	8	0	0	0	0	1	1
New Hampshire	0	0	0	7	8	3	0	0	0	0	0	0
Vermont	1	0	0	14	4	3	0	0	0	0	0	0
Massachusetts	0	0	0	316	254	162	0	0	0	9	2	2
Rhode Island	0	0	0	24	9	9	0	0	0	0	0	0
Connecticut	2	1	0	42	39	45	0	0	0	0	0	0
MIDDLE ATLANTIC												
New York	10	3	2	563	251	288	0	0	0	3	4	7
New Jersey	2	0	1	88	126	126	0	0	0	1	0	2
Pennsylvania	2	1	1	308	204	186	0	0	0	2	2	9
EAST NORTH CENTRAL												
Ohio	1	2	0	190	667	142	1	0	1	1	5	4
Indiana	3	0	0	23	31	31	0	0	2	2	1	2
Illinois	0	0	1	202	100	100	0	0	2	0	0	5
Michigan [3]	0	1	1	233	113	129	0	0	0	0	2	1
Wisconsin	1	0	0	153	110	82	4	0	0	0	0	0
WEST NORTH CENTRAL												
Minnesota	0	1	0	45	62	44	1	0	0	0	1	0
Iowa	0	0	0	25	21	21	0	0	1	0	0	0
Missouri	0	0	0	38	25	25	0	0	1	0	2	5
North Dakota	0	0	0	14	7	3	0	0	0	0	0	0
South Dakota	0	0	0	5	22	5	0	0	0	0	0	0
Nebraska	0	0	0	34	14	6	0	0	0	0	0	0
Kansas	0	1	1	49	33	23	1	0	0	0	2	2
SOUTH ATLANTIC												
Delaware	0	0	0	2	4	4	0	0	0	0	0	0
Maryland [2]	0	0	0	92	76	32	0	0	0	0	1	1
District of Columbia	0	0	0	25	24	10	0	0	0	0	0	1
Virginia	3	4	2	49	12	12	0	0	0	2	5	3
West Virginia	2	0	0	27	17	13	0	0	0	0	3	3
North Carolina	2	17	0	40	12	11	0	0	0	0	4	4
South Carolina	7	1	1	2	2	1	0	0	0	3	9	5
Georgia	2	0	0	10	13	7	2	0	0	10	7	10
Florida	0	5	1	5	5	1	0	0	0	4	4	4
EAST SOUTH CENTRAL												
Kentucky	0	3	1	24	10	21	0	0	0	7	5	2
Tennessee	3	2	1	33	16	17	0	1	1	6	6	3
Alabama	8	3	1	18	4	7	0	0	0	4	2	3
Mississippi [3]	0	2	0	3	2	2	0	2	0	3	4	2
WEST SOUTH CENTRAL												
Arkansas	1	2	2	10	4	4	0	0	0	11	4	5
Louisiana	1	5	2	14	2	3	0	0	0	6	7	7
Oklahoma	0	1	1	4	6	7	0	0	0	1	5	3
Texas	37	4	2	49	36	18	0	0	1	17	8	15
MOUNTAIN												
Montana	0	0	0	13	10	6	0	5	0	0	0	0
Idaho	0	1	0	9	7	5	0	0	0	1	0	0
Wyoming	0	0	0	3	11	7	0	0	0	0	0	0
Colorado	0	0	0	28	22	22	0	0	0	0	2	1
New Mexico	0	0	0	6	11	4	0	0	0	1	2	2
Arizona	0	2	0	9	11	5	1	0	0	3	3	1
Utah [3]	2	0	0	4	31	8	0	0	0	0	0	0
Nevada	0	0	0	0	1	0	0	0	0	1	0	0
PACIFIC												
Washington	0	0	0	43	81	21	1	0	0	3	0	0
Oregon	1	0	0	18	39	9	0	0	0	2	4	1
California	5	9	9	303	223	105	0	0	0	3	3	4
Total	96	71	42	3,246	2,810	2,031	11	8	25	106	110	118
24 weeks	999	657	646	123,662	138,084	89,533	235	259	560	1,507	1,900	2,057

[2] Period ended earlier than Saturday.

[3] Including paratyphoid fever reported separately as follows: Massachusetts 8; New York 1; New Jersey 1; South Carolina, 1; Georgia, 2; Florida, 1; Texas, 1; Washington, 2; Oregon, 2; California, 1.

Telegraphic morbidity reports from State health officers for the week ended June 16, 1945, and comparison with corresponding week of 1944 and 5-year median—Con.

Division and State	Whooping cough			Week ended June 16, 1945							
	Week ended—		Median 1940–44	Dysentery			Encephalitis, infectious	Rocky Mt. spotted fever	Tularemia	Typhus fever	Undulant fever
	June 16, 1945	June 17, 1944		Amebic	Bacillary	Unspecified					
NEW ENGLAND											
Maine	44	17	20	0	0	0	0	0	0	0	1
New Hampshire	3	0	3	0	0	0	0	0	0	0	0
Vermont	17	10	15	0	0	0	0	0	0	0	3
Massachusetts	178	63	156	2	0	0	0	0	0	0	1
Rhode Island	14	16	20	0	0	0	0	0	0	0	0
Connecticut	39	43	44	0	0	0	0	0	0	0	2
MIDDLE ATLANTIC											
New York	203	165	259	4	20	0	3	1	0	1	4
New Jersey	130	60	110	0	0	0	0	2	0	0	1
Pennsylvania	179	63	237	1	0	0	0	0	0	0	7
EAST NORTH CENTRAL											
Ohio	121	99	172	0	0	0	0	0	0	0	3
Indiana	17	16	34	0	0	0	0	3	0	0	0
Illinois	54	33	96	0	1	0	0	0	2	0	15
Michigan [2]	44	66	237	3	1	0	0	0	0	0	14
Wisconsin	31	52	144	0	0	0	0	0	1	0	2
WEST NORTH CENTRAL											
Minnesota	12	14	25	2	1	0	0	0	0	0	4
Iowa	0	4	23	0	0	0	0	0	0	0	0
Missouri	15	37	37	0	0	0	0	0	0	0	2
North Dakota	0	1	2	0	0	0	0	0	0	0	1
South Dakota	2	13	3	0	0	0	0	0	0	0	0
Nebraska	2	12	11	0	0	0	0	0	0	0	0
Kansas	40	26	43	0	1	0	0	0	1	0	2
SOUTH ATLANTIC											
Delaware	0	0	1	0	0	0	0	0	0	0	0
Maryland [3]	69	57	76	0	0	0	0	[4] 2	0	0	0
District of Columbia	11	2	16	0	0	0	0	0	0	0	0
Virginia	71	92	92	0	0	8	0	3	0	0	0
West Virginia	16	15	31	1	1	0	0	2	0	0	1
North Carolina	188	166	168	0	1	0	0	1	0	2	0
South Carolina	61	145	131	1	46	0	0	0	0	4	0
Georgia	22	12	29	0	1	0	0	2	1	15	4
Florida	7	16	16	0	2	0	0	0	0	12	0
EAST SOUTH CENTRAL											
Kentucky	57	87	48	0	0	0	0	0	0	1	2
Tennessee	54	21	59	0	0	1	2	1	1	1	1
Alabama	44	23	51	0	0	0	0	0	1	3	3
Mississippi [2]	----	----	----	0	0	0	0	0	0	2	0
WEST SOUTH CENTRAL											
Arkansas	19	7	17	0	1	0	0	0	4	0	3
Louisiana	4	1	9	0	0	0	0	0	0	3	0
Oklahoma	10	36	27	1	2	0	0	1	0	0	1
Texas	297	199	261	14	492	36	0	0	0	49	25
MOUNTAIN											
Montana	2	18	16	0	0	0	2	0	0	0	0
Idaho	3	0	1	0	2	0	0	0	0	0	0
Wyoming	9	6	3	0	0	0	0	2	0	0	0
Colorado	16	13	18	0	0	0	0	1	1	0	0
New Mexico	6	3	13	1	0	3	0	0	0	0	0
Arizona	4	4	23	0	0	21	1	0	0	0	0
Utah [2]	52	52	91	0	0	0	0	0	1	0	1
Nevada	0	0	0	0	0	0	0	0	0	0	0
PACIFIC											
Washington	14	19	40	0	0	0	0	0	0	0	1
Oregon	15	7	27	0	0	1	0	1	0	0	7
California	422	104	292	2	3	0	2	0	0	1	4
Total	2,618	1,915	3,721	32	575	70	10	22	13	94	115
Same week, 1944	1,915	----	----	31	745	213	9	21	11	97	69
Average, 1942–44	3,326	----	----	43	527	165	7	[5] 18	22	[5] 70	----
24 weeks, 1945	60,055	----	----	743	10,493	2,760	166	[4] 13	376	1,364	2,177
24 weeks, 1944	43,418	----	----	622	7,485	2,122	265	110	268	1,198	1,484
Average, 1942–44	77,607	----	[5]91,802	632	5,082	1,607	246	[5] 139	388	[5] 896	----

[2] Period ended earlier than Saturday.
[3] Delayed report: Maryland 1 case.
[5] 5-year median, 1940–44.
Psittacosis: Pennsylvania 1 case.

WEEKLY REPORTS FROM CITIES

City reports for week ended June 9, 1945

This table lists the reports from 88 cities of more than 10,000 population distributed throughout the United States, and represents a cross section of the current urban incidence of the diseases included in the table.

	Diphtheria cases	Encephalitis, infectious, cases	Influenza		Measles cases	Meningitis, meningococcus, cases	Pneumonia deaths	Poliomyelitis cases	Scarlet fever cases	Smallpox cases	Typhoid and paratyphoid fever cases	Whooping cough cases
			Cases	Deaths								
NEW ENGLAND												
Maine:												
Portland	0	0	-----	0	0	1	1	0	4	0	0	3
New Hampshire:												
Concord	0	0	-----	0	5	0	0	0	0	0	0	0
Vermont:												
Barre	0	0	-----	0	34	0	0	0	1	0	0	1
Massachusetts:												
Boston	0	0	-----	0	143	4	14	0	65	0	0	54
Fall River	0	0	-----	0	1	0	1	0	5	0	0	0
Springfield	0	0	-----	0	0	0	0	0	15	0	0	0
Worcester	0	0	-----	0	39	0	4	0	11	0	0	6
Rhode Island:												
Providence	0	0	-----	0	11	1	2	0	2	0	0	16
Connecticut:												
Bridgeport	0	0	-----	0	0	0	1	0	4	0	0	0
Hartford	0	0	-----	0	32	0	1	0	11	0	0	0
New Haven	0	0	-----	0	1	0	0	0	1	0	0	8
MIDDLE ATLANTIC												
New York:												
Buffalo	0	0	-----	0	6	1	4	3	8	0	0	0
New York	5	0	2	2	87	11	50	4	248	0	4	72
Rochester	0	0	-----	1	21	1	3	2	16	0	2	12
Syracuse	0	0	-----	0	0	0	2	0	1	0	0	34
New Jersey:												
Camden	1	0	-----	0	6	0	1	0	3	0	0	0
Newark	0	0	1	0	6	0	6	0	17	0	0	9
Trenton	0	0	-----	0	3	0	0	0	1	0	0	5
Pennsylvania:												
Philadelphia	2	0	-----	0	469	4	24	0	90	0	0	82
Pittsburgh	0	0	-----	0	2	4	5	0	31	0	0	13
Reading	0	0	-----	0	1	0	1	0	25	0	0	0
EAST NORTH CENTRAL												
Ohio:												
Cincinnati	0	0	-----	1	9	0	4	0	12	0	0	16
Cleveland	2	0	1	0	15	4	8	0	48	0	0	36
Columbus	0	0	-----	0	2	0	2	0	17	0	0	7
Indiana:												
Fort Wayne	0	0	-----	0	0	0	0	0	3	0	0	0
Indianapolis	1	0	-----	0	15	0	4	0	14	0	0	5
South Bend	0	0	-----	0	0	0	0	0	1	0	0	0
Terre Haute	0	0	-----	0	0	0	1	0	1	0	0	1
Illinois:												
Chicago	1	0	-----	0	228	11	29	0	105	0	1	25
Springfield	0	0	-----	0	3	0	0	0	2	0	0	0
Michigan:												
Detroit	7	1	-----	0	141	1	4	0	79	0	0	12
Flint	0	0	-----	0	7	0	1	0	24	0	0	2
Grand Rapids	0	0	-----	0	4	0	0	0	9	0	0	1
Wisconsin:												
Kenosha	0	0	-----	0	10	0	0	0	2	0	0	2
Milwaukee	0	0	-----	0	40	2	2	0	61	0	0	0
Racine	0	0	-----	0	0	0	0	0	6	0	0	6
Superior	0	0	-----	0	1	0	0	0	0	0	0	0
WEST NORTH CENTRAL												
Minnesota:												
Duluth	0	0	-----	0	0	0	2	0	9	0	0	0
Minneapolis	0	0	-----	0	12	1	5	0	36	0	0	9
St. Paul	1	0	-----	0	2	0	2	0	4	0	0	1
Missouri:												
Kansas City	0	0	-----	1	12	0	5	0	7	0	0	2
St. Joseph	0	0	-----	0	1	0	0	0	5	0	0	0
St. Louis	1	0	4	1	14	5	4	0	21	0	0	15

City reports for week ended June 9, 1945—Continued

	Diphtheria cases	Encephalitis, infectious, cases	Influenza		Measles cases	Meningitis, meningococcus, cases	Pneumonia deaths	Poliomyelitis cases	Scarlet fever cases	Smallpox cases	Typhoid and paratyphoid fever cases	Whooping cough cases
			Cases	Deaths								
WEST NORTH CENTRAL—continued												
Nebraska:												
Omaha	1	0	------	0	1	1	3	0	15	0	0	0
Kansas:												
Topeka	0	0	------	0	1	0	0	0	4	0	0	0
Wichita	0	0	------	0	0	1	2	0	6	0	0	2
SOUTH ATLANTIC												
Delaware:												
Wilmington	0	0	------	0	1	0	2	0	0	0	0	0
Maryland:												
Baltimore	9	0	------	0	1	0	7	0	60	0	0	73
Cumberland	0	0	------	0	0	0	1	0	5	0	0	1
Frederick	0	0	------	0	0	0	0	0	0	0	0	0
District of Columbia:												
Washington	0	0	------	0	2	1	9	0	21	0	0	3
Virginia:												
Lynchburg	0	0	------	0	2	0	0	0	1	0	0	1
Richmond	0	0	------	0	9	0	1	1	3	0	0	0
Roanoke	0	0	------	0	0	0	0	0	1	0	0	0
West Virginia:												
Wheeling	0	0	------	0	2	1	0	0	0	0	0	0
North Carolina:												
Raleigh	0	0	------	0	1	0	0	0	0	0	0	6
Wilmington	0	0	------	0	2	0	1	0	1	0	0	6
Winston-Salem	0	0	------	0	0	1	1	0	2	0	0	12
South Carolina:												
Charleston	0	0	1	0	1	0	0	0	0	0	0	0
Georgia:												
Atlanta	0	0	------	0	0	0	3	0	1	0	0	0
Brunswick	0	0	------	0	0	0	2	0	0	0	0	0
Savannah	0	0	------	0	0	0	2	0	1	0	0	1
Florida:												
Tampa	0	0	------	0	0	0	3	1	0	0	3	0
EAST SOUTH CENTRAL												
Tennessee:												
Memphis	0	0	------	1	13	0	10	1	6	0	0	5
Nashville	0	0	------	2	0	0	3	0	1	0	0	0
Alabama:												
Birmingham	0	0	------	0	0	0	1	1	1	0	0	1
Mobile	1	0	1	0	0	0	3	0	1	0	0	0
WEST SOUTH CENTRAL												
Arkansas:												
Little Rock	0	0	------	0	5	0	2	0	0	0	0	0
Louisiana:												
New Orleans	1	1	1	0	11	0	4	1	12	0	0	2
Shreveport	0	0	------	0	0	0	2	0	0	0	0	0
Texas:												
Dallas	1	0	------	0	8	0	1	0	5	0	0	10
Galveston	0	0	------	0	0	0	0	0	0	0	0	0
Houston	0	0	------	1	2	0	4	10	3	0	0	0
San Antonio	0	0	------	0	3	0	3	2	1	0	1	1
MOUNTAIN												
Montana:												
Billings	0	0	------	0	0	0	0	0	2	0	0	0
Great Falls	0	0	------	0	0	0	0	0	0	0	0	0
Helena	0	0	------	0	0	0	0	0	0	0	0	0
Missoula	0	0	------	0	3	0	2	0	0	0	0	0
Idaho:												
Boise	0	0	------	0	0	0	0	0	0	0	0	0
Colorado:												
Denver	0	0	16	1	4	0	4	0	11	0	0	16
Pueblo	0	0	------	0	0	0	1	0	2	0	0	1
Utah:												
Salt Lake City	0	0	------	0	92	0	2	0	4	0	0	3

City reports for week ended June 9, 1945—Continued

	Diphtheria cases	Encephalitis, infectious, cases	Influenza		Measles cases	Meningitis, meningococcus, cases	Pneumonia deaths	Poliomyelitis cases	Scarlet fever cases	Smallpox cases	Typhoid and paratyphoid fever cases	Whooping cough cases
			Cases	Deaths								
PACIFIC												
Washington:												
Seattle	0	0	------	1	33	0	4	0	7	0	0	1
Spokane	0	0	1	1	1	0	2	0	1	0	0	0
Tacoma	2	0	------	0	46	0	1	0	3	0	0	5
California:												
Los Angeles	2	0	2	0	71	1	2	0	43	0	0	55
Sacramento	2	0	------	0	27	0	2	0	25	0	0	4
San Francisco	0	0	------	0	196	2	6	2	32	0	0	13
Total	40	2	30	13	1,921	59	289	28	1,306	0	11	677
Corresponding week, 1944	47	------	22	14	3,027	------	262	------	1,003	0	15	335
Average, 1940–44	58	------	42	[1] 13	[2] 4,362	------	[1] 283	------	1,002	1	21	1,041

[1] 3-year average, 1940–42.
[2] 5-year median, 1940–44.

Dysentery, amebic.—Cases: New York 3; Detroit 1; St. Louis 1; Los Angeles 1.
Dysentery, bacillary.—Cases: Buffalo 2; New York 13; Detroit, 1; Charleston, S. C., 30.
Dysentery, unspecified.—Cases: Baltimore 1; Richmond 1; San Antonio, 27.
Typhus fever, endemic.—Cases: Wilmington, N. C., 1; Savannah 3; Tampa 1; Birmingham 3; Mobile 2; New Orleans 1; Shreveport 1; Dallas 1; Houston 3; San Antonio 1.

Rates (annual basis) per 100,000 population, by geographic groups, for the 88 cities in the preceding table (estimated population, 1943, 34,289,700)

	Diphtheria case rates	Encephalitis, infectious, case rates	Influenza		Measles case rates	Meningitis, meningococcus, case rates	Pneumonia death rates	Poliomyelitis case rates	Scarlet fever case rates	Smallpox case rates	Typhoid and paratyphoid fever case rates	Whooping cough case rates
			Case rates	Death rates								
New England	0.0	0.0	0.0	0.0	695	15.7	62.7	0.0	311	0.0	0.0	230
Middle Atlantic	3.7	0.0	1.4	1.4	278	9.7	44.4	4.2	204	0.0	2.8	105
East North Central	6.7	0.6	0.6	0.6	289	10.9	33.4	0.0	234	0.0	0.6	69
West North Central	6.0	0.0	8.0	4.0	86	16.1	46.3	0.0	215	0.0	0.0	58
South Atlantic	15.1	0.0	1.7	0.0	35	5.0	53.6	3.3	161	0.0	5.0	172
East South Central	5.9	0.0	5.9	17.7	77	0.0	100.3	11.8	53	0.0	0.0	35
West South Central	5.7	2.9	2.9	2.9	83	0.0	45.9	37.3	60	0.0	2.9	37
Mountain	0.0	0.0	127.1	7.9	786	0.0	71.5	0.0	151	0.0	0.0	159
Pacific	9.5	0.0	4.7	3.2	591	4.7	26.9	3.2	176	0.0	0.0	123
Total	6.1	0.3	4.6	2.0	293	9.0	44.1	4.3	199	0.0	1.7	103

TERRITORIES AND POSSESSIONS

Panama Canal Zone

Notifiable diseases—April 1945.—During the month of April 1945, certain notifiable diseases were reported in the Panama Canal Zone and terminal cities as follows:

Disease	Panama		Colon		Canal Zone		Outside the Zone and terminal cities		Total	
	Cases	Deaths	Cases	Deaths	Cases	Deaths	Cases	Deaths	Cases	Deaths
Chickenpox	14				11		2		27	
Diphtheria	6								6	
Dysentery:										
Amebic	5				1		6	1	12	1
Bacillary	1		1		1		2		5	
Leprosy						2	1		1	2
Malaria [1]	5				48	1	72	3	125	4
Measles					7		1		8	
Paratyphoid fever			1		1				2	
Pneumonia		4		2	13	1			[2] 13	7
Poliomyelitis						1				1
Tuberculosis		16		2	9	1		8	[2] 9	27
Typhoid fever			2				1		3	
Whooping cough				1	1				[2] 1	1

[1] 19 recurrent cases.
[2] In the Canal Zone only.

FOREIGN REPORTS

CANADA

Provinces—Communicable diseases—Week ended May 26, 1945.—During the week ended May 26, 1945, cases of certain communicable diseases were reported by the Dominion Bureau of Statistics of Canada as follows:

Disease	Prince Edward Island	Nova Scotia	New Brunswick	Quebec	Ontario	Manitoba	Saskatchewan	Alberta	British Columbia	Total
Chickenpox		38	1	239	231	47	11	49	95	711
Diphtheria		9	5	37	4	6				61
Dysentery, bacillary									1	1
German measles		1		8	41	5	3	23	55	136
Influenza		63			67	2			61	193
Measles		6		146	230	37	66	49	359	893
Meningitis, meningococcus				3	3			1	2	9
Mumps		4		182	87	23	8	87	29	420
Poliomyelitis					1					1
Scarlet fever		2	14	73	60	16	4	28	17	214
Tuberculosis (all forms)		3	4	97	39	11	4	11	75	244
Typhoid and paratyphoid fever				12	1	1	1	1	1	17
Undulant fever				6					3	9
Venereal diseases:										
Gonorrhea		13	5	73	124	48	22	39	52	376
Syphilis		11	4	107	69	9	4	5	22	231
Whooping cough		8		193	42		5		9	257

JAMAICA

Notifiable diseases—4 weeks ended June 2, 1945.—During the 4 weeks ended June 2, 1945, cases of certain notifiable diseases were reported in Kingston, Jamaica, and in the island outside of Kingston, as follows:

Disease	Kingston	Other localities	Disease	Kingston	Other localities
Cerebrospinal meningitis	1		Leprosy		4
Chickenpox	25	41	Tuberculosis	43	54
Diphtheria	7	2	Typhoid fever	8	114
Dysentery	7	8	Typhus fever	2	1
Erysipelas	2	1			

REPORTS OF CHOLERA, PLAGUE, SMALLPOX, TYPHUS FEVER, AND YELLOW FEVER RECEIVED DURING THE CURRENT WEEK

NOTE.—Except in cases of unusual incidence, only those places are included which had not previously reported any of the above-named diseases, except yellow fever, during the current year. All reports of yellow fever are published currently.

A table showing the accumulated figures for these diseases for the year to date is published in the PUBLIC HEALTH REPORTS for the last Friday of each month.

(Few reports are available from the invaded countries of Europe and other nations in war zones.)

Plague

Morocco (French).—For the period May 25–31, 1945, 72 cases of plague were reported in French Morocco.

Peru.—During the month of April 1945, plague was reported in Peru by Departments as follows: Ica, 1 case, 1 death; Libertad, 2 cases; Lima, 2 cases; Piura, 1 case. One case of suspected plague was also reported in the Department of Cajamarca, Peru.

Smallpox

Sudan (French).—For the period May 21–31, 1945, 110 cases of smallpox were reported in French Sudan.

Typhus Fever

Iraq.—For the week ended June 9, 1945, 13 cases of typhus fever were reported in Iraq.

Mexico—Nuevo Laredo.—A telegraphic report dated June 19, 1945, states that 18 cases of endemic typhus fever with 1 death have occurred in Nuevo Laredo, Mexico.

Morocco (French).—For the period May 25–31, 1945, 246 cases of typhus fever, including 8 cases in Casablanca and 2 cases in Rabat, were reported in French Morocco.

Turkey.—For the week ended June 9, 1945, 66 cases of typhus fever were reported in Turkey, including 1 case in Adana, 3 cases in Istanbul, and 6 cases in Zonguldak.

Yellow Fever

Gold Coast—Takoradi.—On June 8, 1945, 1 fatal case of yellow fever was reported in Takoradi with the place of onset as Nsuta, Gold Coast.

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COURT DECISION ON PUBLIC HEALTH

Hotels—regulation.—(Arkansas Supreme Court; *City of Texarkana* v. *Brachfield,* 183 S.W.2d 304; decided October 23, 1944, as amended on denial of rehearing December 4, 1944.) In this case one of the conclusions reached by the Supreme Court of Arkansas was that a city of the first class in the State had, under an 1885 statute (Pope's Digest, section 9944), the power to regulate hotels, the limit of the power being the protection of the morals, health, and safety of the city. In this connection the court cited in its opinion a later statute (Act 210 of 1917) which empowered the State board of health to promulgate sanitary rules for hotels and to have some form of inspection. While, according to the court, such 1917 law did not take away from first-class cities the power over hotels as allowed by section 9944, it was pointed out that the rules and inspections made by the State board of health, within the scope of the purpose in view when the 1917 act was passed, were superior to any municipal regulation, since the State board of health authority was the latest legislative expression.

The court referred to an Indiana case in which the supreme court of that State pointed out that the action of the State legislature in empowering the State board of health to regulate tourist courts did not take away from a municipality the right also to establish reasonable regulations for the protection of the health and safety of the municipality's citizens so long as the municipal regulations were not contrary to the State board of health regulations. Said the Arkansas Supreme Court: "We subscribe to the same holding."

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