Public Health Reports

Vol. 65 • **FEBRUARY 24, 1950** • *No. 8*

Effects of DDT Mosquito Larviciding on Wildlife

V. Effects on Fishes of the Routine Manual and Airplane Application of DDT and Other Mosquito Larvicides

By CLARENCE M. TARZWELL, PH. D.*

Preliminary tests with DDT for the control of mosquitoes, forest insects, and agricultural pests demonstrated that it was toxic to a wide variety of animal life. Because there were indications that the new insecticide would be widely used, apprehension was expressed by some groups that its extensive or indiscriminate use would cause extensive harm to wildlife.

The desirability of carefully controlled use was early recognized by those in charge of extensive programs for the control of insects of public health importance. A joint statement of policy for the use of DDT issued early in 1945 (*1*) by the Army and the Public Health Service announced that widespread use of DDT would be delayed until studies could determine its effects on beneficial insects and higher forms of life. The Fish and Wildlife Service, the Bureau of Entomology and Plant Quarantine, and the Public Health Service have conducted extensive cooperative investigations in several parts of the country. The first two agencies have studied the effects on wildlife of single treatments with large dosages of DDT. The Public Health Service has principally studied the consequences of using small dosages of DDT routinely over considerable periods. Methods of application and frequency of treatment were the same as those commonly used in regular malaria control larviciding programs in order to ascertain at what dosage, if any, and in what manner or physical state DDT might be used in regular malaria control operations without being significantly harmful to organisms of economic or recreational importance.

Investigations were begun late in 1944 (*2*) and a phase of the study, the effect on fishes of several years of routine airplane treatment, was

*Senior Scientist, Technical Development Division, Savannah, Ga., Communicable Disease Center, Atlanta, Ga.

continued into 1948. Intensive reasearch on possible changes in the aquatic biota induced by routine ground application of DDT larvicides was begun and carried out in 1945 (*3*). In 1946, studies were begun on the consequences of airplane application, and the inquiry was broadened to include not only the aquatic forms but also reptiles, birds, mammals, and terrestrial insects in marginal areas. Moreover, DDT and several of the newer insecticides were applied routinely, at several dosages, to small deep water ponds by means of air pressure hand sprayers in order to determine their comparative after-effects on aquatic life.

In 1947, tests were limited to the determination of the consequences of routine airplane larviciding on fishes, and further observations were made on the use of DDT and DDD in small ponds.

During 1948, two areas were routinely larvicided by airplane and, as in former seasons, fish population studies were made at the end of the season for the determination of any effects on the standing fish populations.

Effects of Manual Application

Studies of the effects of manual dispersions of DDT larvicides were conducted on 64 coastal plain ponds lying within a 20-mile radius from Savannah, Georgia. Most of these ponds had sand bottoms and several had a minimum of rooted aquatic vegetation or organic debris. Preliminary inquiries on several DDT solvents and various formulations of DDT dusts, emulsions, and solutions were made on 42 of the ponds for the determination of the most desirable methods of application, types of larvicidal preparations, and dosages of DDT to use in the routine intensive studies made on 22 ponds.

Several types of dusters and doses of 0.1 to 0.4 pound of DDT per acre were used in the preliminary dust tests. The Hudson rotary duster and a dust mixture consisting of 1 part DDT and 99 parts pyrophyllite were selected for the routine studies. This dust was applied at the rate of 10 pounds per acre, giving a dose of 0.1 pound of DDT per acre. Air pressure hand sprayers were employed for the dispersion of solutions and emulsions. Emulsions were sprayed uniformly over the surface of the ponds at the rate of 15 gallons per acre and at dosages of 0.05 to 0.2 pound of DDT per acre. These were made by adding 1 gallon of a solution consisting of DDT, emulsifier, and fuel oil or some other solvent to 14 gallons of water. Solutions were applied by air pressure hand sprayers, equipped with atomizing nozzles, at rates of 0.5 to 2 gallons per acre and dosages of from 0.025 to 2 pounds of DDT. Routine treatments were made at weekly intervals. All ponds were seined prior to treatment to determine the species of fish present and to gain some idea of their relative abundance. Observations for the detection of dead fish were made in untreated and

treated ponds just before use of the larvicide and 24 and/or 48 hours thereafter. At the completion of treatment, the ponds were seined or the fish poisoned to ascertain the remaining population.

Results

Preliminary tests were made with 15 different solvents employed separately at rates of 0.5 to 2 gallons per acre or combined with DDT at the rate of 0.1 pound per acre. In trials at 1 gallon per acre, Dioxane, turpentine, methyl alcohol, and butyl alcohol did not kill fish, but they were toxic as indicated by the decimation of aquatic insects. Isopropyl alcohol, ethyl alcohol, and acetone were much less toxic as indicated by the smaller number of surface aquatic insects killed. Different samples of No. 2 fuel oil varied greatly in toxicity. In general, fuel oil was found to be more toxic than kerosene, alcohol, acetone or Arosol; about as toxic as Solvesso No. 1 and 3 and Mentor No. 28; but less toxic than Velsicol NR–70.[1] However, when used with DDT at 0.1 pound per acre, these solutions are much more toxic than any of the solvents tested when they are applied alone at a rate of 1 gallon per acre. When utilized alone at rates of 2 gallons per acre, Velsicol NR–70 and fuel oil No. 2 caused a noteworthy effect on surface insects. Velsicol NR–70 produced a distinct persistent scum-like film and was the most toxic solvent tested. If DDT solutions are to be employed at rates of 2 gallons per acre, it would seem desirable to use kerosene or some of the less toxic solvents in preference to Velsicol or fuel oil No. 2; but used at an application rate of 1 gallon of DDT solution per acre, the difference between most samples of No. 2 fuel oils and kerosene does not appear to be significant.

It early became apparent that stable DDT emulsions were more toxic to amphibians, fishes, larger crustacea, and several orders of aquatic insects than were DDT solutions and dusts. Similar conclusions were reached by Eide, Deonier, and Burrell (*7*) on the basis of their field studies, and by Ginsburg (*8*) on the basis of his preliminary laboratory tests. It was also found that single applications of DDT solutions applied at dosages of 0.4 pound or more of DDT per acre were toxic to fish. One application at 0.4 pound per acre killed only a few fish, but single applications of 1 to 2 pounds per acre killed most or all of the fish. Single applications of solutions at a dosage of 0.1, 0.05, and 0.025 pound per acre and dusts at 0.1 or 0.2 pound of DDT per acre did not kill fish. Stable emulsions and solutions applied at the rate of 0.4 pound or more per acre were therefore abandoned in favor of dusts or solutions applied at the rate of 0.1, 0.05, or 0.025 pound of DDT per acre for routine applications in the 22 ponds to be studied intensively.

A woodland pond, just above the tidal zone at the outskirts of

[1] The use of a trade name does not represent an endorsement of the product by the Public Health Service.

Savannah, was routinely dusted 26 times at an average rate of 0.2 pound of DDT per acre. This pond had considerable organic bottom materials and emergent vegetation over about a third of its area. During the period of testing, only one dead fish, *Gambusia affinis holbrookii*, and one dead crab were found. Seining before and after treatment indicated little or no change in the fish population. Fishes present were *Mugil cephalus*, *Cyprinus carpio*, *Anchoa mitchilli*, *Mollienisia latipinna*, *Fundulus heteroclitus heteroclitus*, *Gambusia affinis holbrookii*, *Fundulus chrysotus*, *Cyprinodon v. variegatus*, *Trinectes maculatus fasciatus*, *Gobionellus shufeldti*, and *Micropogon undulatus*.

A series of tests was conducted in three areas of one of the large ponds in the Savannah River Migratory Waterfowl Refuge. This pond had a thick layer of organic debris over its bottom and considerable floating and emergent vegetation. The most common plant forms were cutgrass (*Zizaniopsis miliacea*), waterlily (*Nymphaea odorata*), jussiaea (*Jussiaea leptocarpa*), alligator-grass (*Alternanthera philoxeroides*), pickerelweed (*Pontederia lanceolata*), and watershield (*Brasenia schreberi*). Three similar adjacent areas were chosen for study. Two areas were treated and the third was kept as an untreated check. The treated areas were contiguous and separated from each other and the large pond by means of a barrier seine, a waterproofed canvas provided with lead and float lines and held in place by stakes (*9*). These ponds were treated weekly for 18 weeks, one being dusted at the rate of 0.1 pound of DDT per acre and the other sprayed with a mist spray of 1 gallon of fuel oil and 0.05 pound of DDT per acre. Weekly observations were made for the detection of fish kill. Gross observations indicated that the fauna of the plot receiving the oil spray was more affected than that of the dust plot. Some spotting of the vegetation by the oil was noted after each treatment, but such changes disappeared before the next treatment, and the aquatic vegetation thrived throughout the period of study. After the fourth spraying, a crab, *Callinectes sapidus*, a frog, and a fish, *Fundulus dispar lineolatus*, were found dead. No dead fish were detected in the dusted or check pond.

A series of observations, using several dosages of DDT, was made on 14 small artificial ponds. Well water was piped to these ponds, and the water level was kept fairly constant by means of float valves. The ponds were filled early in the season and stocked with plankton, aquatic insects, bottom organisms, and fish which readily became established. Beds of *Chara* developed rapidly. Weekly treatments were begun August 1, 1945, a total of 18 being applied. Table 1 indicates the nature of each test and its biological consequences. Ponds 5, 6, 7, 8, 10, 11, 12, 13, and 14 were small, measuring 5 by 15 feet and having an average depth of about 6 inches. Ponds 1 and 2

Table 1.—*Summary of the fish kill in 14 experimental ponds by specified dosages of DDT applied in 18 weekly treatments and the number of fish remaining at the end of the treatment as indicated by poisoning (K=killed; A=alive)*

Treatment	Untreated check ponds						Fuel oil		Dust				DDT dissolved in No. 2 fuel oil															
Dosage	None						1 gallon per acre		0.1 pound DDT per acre				0.025 pound per acre				0.05 pound per acre				0.1 pound DDT per acre							
Ponds	5		10		11		6		2		12		14		15		13		16		1		8		17			
	K	A	K	A	K	A	K	A	K	A	K	A	K	A	K	A	K	A	K	A	K	A	K	A	K	A		
Gambusia affinis holbrookii	--	8	--	335	--	922	--	1	--	--	4	373	--	4	--	18	1	75	5	1	--	--	3	--	13	--		
Fundulus dispar lineolatus	--	--	--	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--		
F. chrysotus	--	1	--	25	--	--	--	--	--	--	--	--	--	--	--	--	--	--	5	2	--	--	2	--	12	--		
Heterandria formosa	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	9	--	--	2	5	--	--	--	--	3	--		
Ameiurus nebulosus marmoratus	--	--	--	--	--	1	--	--	--	--	--	--	--	--	--	9	--	--	15	--	--	--	--	--	1	--		
A. natalis erebennus	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	3	--	--	--	--	5	--		
Chaenobryttus coronarius	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1	--	--	1	--	--	--	--	--	1	--		
Enneacanthus obesus	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	5	--	--	--	--	--	--	--		
Anguilla bostoniensis	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1	--	--	--	--	--	--	--	--	--	--		
Crayfish	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1	--	13	--	1	--	--	--	--		
Tadpoles	--	--	--	1	--	51	--	--	--	--	2	162	2	--	--	1	--	--	--	--	--	--	--	--	--	--		
Totals	0	9	0	362	0	974	0	1	0	All	6	535	2	4	0	39	1	76	33	11	13	0	6	0	35	0		

were the same size but had concrete bottoms and were about 1 foot deep. Fish plantings in the small ponds were largely confined to top minnows. Three ponds were larger; pond 15 measured 12 by 28 feet; pond 16, 14 by 28 feet; and pond 17, 30 by 30 feet. These ponds ranged in depth from 6 to 10 inches, and larger fish were placed in them. Fish stocking in the various ponds was not uniform as to number.

As indicated in table 1, no reduction in fish numbers was noted in the untreated check ponds, and large fish populations were present in two of them at the termination of the study. There was no observed harm to fish in the pond treated with 1 gallon of fuel oil per acre. Killing was insignificant in the ponds dusted at the rate of 0.1 pound of DDT per acre, and no dead fish were found in the ponds routinely sprayed at a dosage of 0.025 pound of DDT per acre. There was a pronounced decimation in one of the ponds receiving 0.05 pound of DDT per acre as a spray, but only one dead fish was found in the other one. The routine spray treatments at 0.1 pound of DDT per acre destroyed the fish and crayfish. Only a portion of the fish killed was noted by the weekly observations. Many were taken by fish-eating birds between inspections.

At the end of the season, snails were abundant in all of the treated ponds. The first two treatments at all doses killed most of the crayfish. In the dust-treated pond, the first dead fish was found after the fourteenth treatment. In the ponds sprayed at the rate of 0.05 pound of DDT per acre, the first reduction was noted in one pond after the eighteenth treatment, and in the other, after the eleventh; the next dead fish was found following the thirteenth treatment. In

the ponds treated at the rate of 0.1 pound of DDT per acre, the first deaths were noted after the tenth treatment. The bullheads, *Ameiurus nebulosus marmoratus* and *Ameiurus natalis erebennus*, were the first fishes to show indications of DDT poisoning. Some of these were sick for more than 3 weeks before they died. During this time they lay gasping, turned slightly on their sides. When disturbed, they swam slowly and erratically.

The earliest results were exhibited by the bullheads and not the top minnows as expected. Bullheads may possibly be affected due to their habit of swimming near the bottom so that their barbels drag over it, thus bringing these sensory organs in direct contact with the DDT which has recently settled. Chemical tests made for the determination of the deposition of DDT in ponds 1 and 2 demonstrated a considerable amount on the bottoms. Bottom material of about one-eighth inch in thickness was collected from 2 square-foot areas in these ponds and chemically analyzed for DDT. During the course of the 18 treatments, these ponds had received a total dose of 1.8 pounds of DDT per acre. DDT was found on the bottom of the oil-treated pond in the amount of 0.29 pound per acre, and in the dusted pond 0.83 pound per acre was recovered. This latter amount is almost half the total applied. At the time of analysis, DDT had possibly been absorbed by the soil and was biologically inactive, but after extraction with benzene, it regained its insecticidal properties as ascertained in laboratory tests. It is not known how rapidly or how much DDT can be inactivated by the soil, but the amount must be considerable because there was very little soil on the concrete bottoms of these ponds.

Routine studies were also made on four ponds in the Camp Stewart area near Richmond Hill in Bryan County, Ga. Three of these ponds designated as Nos. 11, 12, and 13 lie in an area annually covered by high flood waters of the Canoochee River and are naturally stocked with fish. Observations were begun after a flood period when these three ponds had been confluent. Thus, their fish populations were originally similar. The ponds differed, however, in that pond 13 had some clay in its bottom while ponds 11 and 12 had sand bottoms, more vegetation, and were deeper. Areas of ponds 11 and 12 were about 0.08 acre, while pond 13 contained 0.14 acre at the beginning of the study. Water levels in the ponds dropped during the course of the work, and the dose was adjusted as their areas decreased. A grass-like *Eleocharis* and a narrow leaf *Potamogeton* were the dominant plants in pond 12. The narrow leaf *Potamogeton* was particularly abundant in pond 11. Pond 13 was fringed with a small grass-like *Eleocharis* and a smart-weed, *Polygonum*, was abundant in one end. The water in ponds 11 and 12 was clear, but cloudy in pond 13. Larviciding was begun September 13, and a total of 11 applications was

Table 2. *Summary of the fish kill and the fish remaining in four experimental ponds after routine weekly treatments with specified dosages of DDT (K=killed; A=alive)*

Character of application	None	DDT in kerosene		DDT in kerosene		DDT in fuel oil No. 2	
Number of treatments	None	11		11		22	
Dosage per treatment	Check	0.1 pound DDT per acre		0.05 pound DDT per acre		0.1 pound DDT per acre	
Ponds	11	12		13		5	
	*A	K	A	K	A	K	A
Lepisosteus platyrhincus							
Erimyzon sucetta sucetta	35	7				5	
Notemigonus crysoleucas bosci	81	3					1
Notropis maculatus	3						1
Ameiurus nebulosas marmoratus						2	5
A. natalis erebennus	322	10	1	13	1		
Esox americanus	3			2		1	
E. niger	2						
Anguilla bostoniensis	1		1	1	1		11
Fundulus chrysotus	202	17				10	1
F. dispar lineolatus	163	2				3	
Leptolucania ommata							11
Heterandria formosa	1,231					1	673
Mollienisia latipinna						12	113
Gambusia affinis holbrookii	2,119	40		1			3
Aphredoderus sayanus	5				2		1
Hololepis barratti	9						
Enneacanthus obesus	121						
E. gloriosus	108	2				2	
Centrarchus macropterus		5				1	
Acantharchus pomotis	1						1
Chaenobryttus coronarius	111	2		1		13	1
Lepomis microlophus microlophus	5	5				5	
L. macrochirus purpurescens	2	4				1	
L. auritus	2	10				4	2
L. marginatus	109	17				9	
L. punctatus punctatus	25	2					
Miscellaneous sunfishes	79	26		3	1	33	6
Huro salmoides	4	3					
Elassoma evergladei	818	2	13		15		1
Labidesthes sicculus vanhyningi	9						
Palaemonetes	19						
Cambarus	93	8	2	2	12		2
Frogs		3					
Tadpoles	877			1	1	3	7
Amphiuma means	1						
Siren sp.	3		2		24		
Natrix sipidon fasciata				2			
Totals	6,563	168	19	26	57	105	840
Fish only	5,570	157	15	21	20	102	831

*None killed.

made. Pond 11 was retained as an untreated check; pond 12 received 0.1 pound of DDT per acre, and pond 13, 0.05 pound per acre dispersed as a mist spray at the rate of 1 and 0.5 gallon per acre, respectively.

No dead fish were found in the check pond. In pond 12 (table 2) the first dead fish, a largemouthed bass and a golden shiner, were found after the second treatment. The third treatment was strikingly lethal with 32 fish being recovered, among which were largemouthed bass, bluegills, warmouth bass, flyer sunfish, golden shiners, top minnows, and a small frog. Fish were found dead following each subsequent treatment. In pond 13, the first reduction of fish numbers was noted after the third treatment, but there was a moderate fish popula-

tion present after the fourth treatment. At that time, one haul of a 20-foot seine across the pond netted the following: long-nosed gar, 1; golden shiners, 15; bullheads, 6; bluegills, 9; other sunfishes, 22; tadpoles, 9; crayfish, 20; and *Palaemonetes*, 9. After the eleventh treatment, a similar haul taken in the same place and in the same manner yielded one *Gambusia* and one *Heterandria*.

A much larger fish population was found in the untreated check pond 11 than in the two treated ponds 12 and 13 (table 2). It is evident that the total fish population was greatly reduced by the treatments in ponds 12 and 13 and that only a fraction of the dead fishes was noted by the weekly inspections. The numbers of fish found dead and the fish remaining at the end of treatment in ponds 12 and 13 possibly indicate that dosages of 0.1 pound of DDT per acre are more toxic than dosages of 0.05 pound per acre.

The other Camp Stewart pond (pond 5) received 22 routine spray treatments at the rate of 0.1 pound of DDT and 1 gallon of fuel oil per acre. This pond is fed by an artesian well, and the water level was kept fairly constant by a connection with a bypass ditch. The first fish kill in this pond was noted after the third treatment, but was less severe than in pond 12. In the latter pond, the recovery of dead fish was several times as great as the number remaining at the end of treatment, whereas in pond 5 the reverse was true. Fish found after individual treatments and at the end of the season are listed in table 2.

Effects of Airplane Application

Studies of the effects of routine airplane larviciding with DDT have been carried on for 3 years in the Savannah Migratory Waterfowl Refuge with the cooperation of the Fish and Wildlife Service. Treatments have been made with a Stearman type PT–17 plane having a 220 horsepower Continental engine. The plane was equipped with a Venturi exhaust generator similar to the one described by Metcalf et al. (*10*) and Krusé and Metcalf (*11*) for the distribution of thermal aerosols and with five nozzles for the application of sprays. These nozzles [2] were placed one at each wing tip, one on the tail, and one on each side of the fuselage inboard of the aileron. When applying the larvicide, the plane flew at 100-foot intervals in parallel lines across the ponds and at an elevation of about 30 feet wherever possible, but trees and other obstacles were given a clearance of about 20 feet. Both sprays and aerosols consisted of a 20 percent solution by weight of technical grade DDT in a methylated naphthalene.[3] The rate of dispersal was approximately 0.1 pound per acre applied at weekly intervals. In 1946, the various areas under test were treated 15 to

[2] LN–12 of the Spraying System Company, Chicago.

[3] Velsicol NR–70, a product of Velsicol Corporation, Chicago.

17 times, but each area received 20 treatments in each of the 1947 and 1948 seasons.

In 1946, airplane larviciding was conducted on some 815 acres contained in four ponds, two of which (ponds 6 and 2) were sprayed while ponds 3A and 3 received a thermal aerosol application. Two untreated check areas, 4 and 4A, were established in an 850-acre pond about a mile from the nearest treated area. Weekly observations were made 24 to 48 hours after treatment in each of the six areas for the detection of any fish mortality. Fish population checks were made in selected 1-acre plots before treatment in two ponds and after treatment in all but one of the ponds.

In 1947, treatment was restricted to ponds 6 and 3A, the former being sprayed and the latter receiving a thermal aerosol as during 1946. Weekly observations were made for the detection of dead fish in treated and untreated areas, and fish population studies were made in these and in the untreated pond following the season's treatment. In 1948, occasional observations were made to detect any destruction of fish, and population determinations were made at the completion of treatment. All fish population studies were made in the 1-acre plots staked out and used in 1946 in order that direct comparisons could be made.

The 1946 treatments were begun the first week of May. Although all ponds were treated at the same rate (0.1 pound per acre), considerably more DDT reached the water surface in the sprayed ponds than in those receiving the thermal aerosol. In order to determine the actual amount of DDT reaching the water surface in each of the ponds, glass slides measuring 3 by 12 inches were placed above water on small platforms set on stakes which were placed at 30- or 40-foot intervals in a "horseshoe" type pattern across the ponds, 12 to each pond. The glass slides were placed the day before treatment, collected after treatment, and the amount of DDT on them determined colorimetrically. The average amount of DDT found on these 12 slides was considered as the amount reaching the water surface.

Pond 6 received a total of 17 treatments with a total dose for the season of 1.64 pounds of DDT per acre. About 53 percent of this reached the water surface, the amount varying from 37 to 96 percent for individual treatments. The calculated average amount of DDT reaching the water surface per treatment was 0.051 ± 0.004 pound per acre.

Pond 2 was sprayed 16 times with a total dose of 1.54 pounds of DDT, about 75 percent of which reached the water surface. The calculated average amount of DDT reaching the water surface per treatment was 0.070 ± 0.006 pound per acre.

Ponds 3A and 3 each received 15 thermal aerosol treatments with a total applied dose for the season of 1.60 pounds of DDT per acre.

Figure 1. Section of barrier seine enclosing area for fish population study.

In pond 3A, an average of about 10 percent of the applied dosage reached the water surface, the amount per application varying from 0.003 to 0.033 pound per acre. The calculated average amount reaching the water surface per treatment was 0.011 ± 0.0004 pound per acre. In pond 3, an average of about 12 percent of the applied dosage reached the water surface, the calculated amount per treatment varying from 0.005 to 0.031 pound per acre and averaging 0.013 ± 0.001 pound per acre.

Ponds at the Savannah River Migratory Waterfowl Refuge are in diked areas which were formerly rice fields. Water levels within the dikes are controlled by tide gates. Ponds 6 and 2 were flooded in January 1945 and thus had a well-established aquatic fauna at the beginning of the study in 1946. Ponds 2, 3, 4 and 4A were flooded in January 1946. In late March and early April 1946, about 500,000 number one fingerling largemouthed bass were planted in these ponds. The newly flooded ponds were more heavily stocked than the older ones, distribution being as follows: pond 2, 51,000; pond 3A, 17,000; pond 3, 77,000; pond 4, 331,000; and pond 6, 24,000. The water area of each pond is as follows: pond 2, 135 acres; pond 3A, 75 acres; pond 3, 175 acres; pond 4–4A, 850 acres; and pond 6, 135 acres.

Fish population studies were made in ponds 6 and 3A at the beginning of treatment and in these and the other ponds at the completion

of treatment, using methods described by Tarzwell (*12*). A square area of about 210 feet on a side was staked out in each pond for the population studies. A barrier seine, consisting of a strip of canvas 6 feet wide, provided with float and lead lines, was placed around these stakes and held in place by stakes placed on the outside (fig. 1). This prevented fish from entering or leaving the area during the population study and helped retain the rotenone used for the poisoning of the fish. The barrier seine was left in place for a week at each location. The fish were poisoned by derris root having a 5 percent rotenone content. The amount of rotenone applied varied from one part in 5 million to one part in 10 million, depending on the water temperature. Fish were picked up immediately after treatment and thereafter as they rose to the surface. All fish taken were separated as to species or genus, then counted and weighed.

Results

Aquatic vegetation, chiefly yellow waterlily and cutgrass, was abundant in pond 6 at the beginning of the study and it increased throughout the period, but one portion of the pond remained relatively free of vegetation. It was in this area where the water averaged 3 to 4 feet deep that the population counts were made. Weekly observations for the detection of dead fish were made throughout the pond. After the first treatment, several dead crabs were seen on the bottom in shallow water near shore. Dead fish were found after the second, fourth, fifth, twelfth, thirteenth, and fourteenth treatments. Total mortality noted was 13 fish, a wood frog, and a water snake. Only a fraction of the dead fish was found, but the total was not significant as indicated by a comparison of the fish population before and after treatment (table 3). These comparisons showed an increase in fish population during the period, and there were no indications that any species was reduced unnaturally.

During the winter of 1946–47, the water level of pond 6 was lowered about 2 feet for the planting of aquatic vegetation. This allowed many fish to escape and reduced the fish population as shown by a fish population study made prior to treatment in April 1947 (table 3). Gross observations made 24 hours after each of the 20 applications made in 1947 showed the following total kills: sunfish, 26; bullheads, 14; golden shiners, 115; flounder, 1; mullet, 1; and frogs, 4. That they were not of great significance is indicated by a slight increase in the fish population during the course of treatment (table 3). The total number of fish taken in the experimental area increased from 1,152 in April to 19,568 in September. This increase clearly shows that the population of the pond had been reduced below the carrying capacity by migration while the gates were open, and that treatment did not prevent an increase in the fish population. No gross observa-

Table 3a. *Effects on fish populations of the routine airplane application of DDT sprays and thermal aerosols at 0.1 pound per acre over a 1- to 3-year period as indicated by fish population studies in 1-acre areas in check and treated ponds at the Savannah River Migratory Waterfowl Refuge before treatment and at the end of each season's operations in 1946, 1947, and 1948*

Species taken	Pond No. 6 sprayed							
	1946				1947			
	Before treatment		After treatment		Before treatment		After treatment	
	Number	Weight	Number	Weight	Number	Weight	Number	Weight
		Pounds		*Pounds*		*Pounds*		*Pounds*
Lepisosteus platyrhincus	13	14.1	31	30.0	4	6.3		
Amia calva	1	3.8	1	1.5			1	4.7
Pomolobus pseudoharengus	2	0.1						
Dorosoma cepedianum	174	53.4	277	95.8				
Brevoortia tyrannus	7	0.1	21	1.0	95	0.3		
Anchoa mitchilli	4		70	0.1				
Erimyzon sucetta sucetta	1	0.6					1	
Cyprinus carpio	1	9.3					4	3.6
Notemigonus crysoleucas bosci	64	1.8	75	1.2	65	2.0	13,178	30.9
N. maculatus							1	
Ictalurus catus	1	0.8	1	0.4	5	7.9	391	4.8
I. catus (fingerlings)	210	0.2	29	0.1				
Ameiurus nebulosus marmoratus	2	1.1	38	6.8			19	0.2
A. n. marmoratus (fingerlings)								
A. natalis erebennus					1	1.8		
Anguilla bostoniensis	81	1.5	24	1.6	1		52	0.7
Esox americanus								
E. niger								
Fundulus chrysotus							9	
Gambusia affinis holbrookii								
Heterandria formosa							24	
Aphredoderus sayanus	1						1	
Chaenobryttus coronarius	13	1.0	953	8.0	115	3.1	31	2.9
C. c. (fingerlings)	22	0.1						
Pomoxis annularis	24	1.8	2	1.3				
P. nigro-maculatus								
Centrarchus macropterus								
Enneacanthus gloriosus	1		5	0.1	811	1.3		
Lepomis macrochirus purpurescens	27	6.2	23	5.5	21	0.8		
L. microlophus microlophus	4	0.3	22	3.4				
L. auritus	32	3.9	12	1.7	9	0.5		
Miscellaneous sunfishes	341	0.5	2,560	4.8	14	0.1	5,816	5.0
Huro salmoides	10	2.6	2	2.4				
H. s. (fingerlings)								
Elassoma evergladei								
Labidesthes sicculus vanhyningi								
Micropogon undulatus	2							
Mugil cephalus	24	13.9	14	11.9	8	15.0		
Gobionellus shufeldti	87	0.1	49	0.2	2	0.1		
Hololepis barratti			54	0.1			40	0.1
Trinectes maculatus fasciatus	25	0.3	21	0.1				
Paralichthys lethostigmus	28	13.8	2	0.2	1	1.4		
P. l. (small)	10	0.1						
Totals	1,212	131.4	4,286	178.2	1,152	*40.6	19,568	52.9

*This marked decrease in the fish population is due to a winter drawdown of some 20 inches which allowed the fish to leave the pond.

tions were made in the 1948 season, and the assay made at the close of treatment showed an increase of over 100 pounds of fish per acre.

The number of fish per acre more than doubled from September 1947 to September 1948 (table 3). Practically all species increased, especially the blue-spotted sunfish, *Enneacanthus gloriosus*. Vegetation appeared in the assay area after September 1947, and by September 1948, *Naias* and *Chara* were matted in the bottom. Increase

Table 3b. *Effects on fish populations of the routine airplane application of DDT sprays and thermal aerosols at 0.1 pound per acre over a 1- to 3-year period as indicated by fish population studies in 1-acre areas in check and treated ponds at the Savannah River Migratory Waterfowl Refuge before treatment and at the end of each season's operations in 1946, 1947, and 1948*

Species taken	Pond No. 6 Sprayed		Pond No. 3A—Thermal Aerosol							
	1948		1946				1947		1948	
	After treatment		Before treatment		After treatment		After treatment		After treatment	
	Number	Weight	Number	Weight	Number	Weight	Number	Weight	Number	Weight
		Lbs.		Lbs.		Lbs.		Lbs.		Lbs.
L. platyrhincus	14	21.7	15	12.9	16	15.1	10	10.0		
A. calva	1	4.4	6	11.4	16	38.3	2	8.3	1	4.8
P. pseudoharengus										
D. cepedianum									2,246	29.0
B. tyrannus			26	.1			27	.6		
A. mitchilli										
E. s. sucetta	23	1.1	13	.5	31	9.9	831	22.3	137	50.2
C. carpio	9	50.4	121	.1						
N. c. bosci	7,948	47.9	1,555	5.4	224	14.7	14,484	42.9	1,741	9.7
N. maculatus	190	.2							6	
I. catus			1	2.4	3	1.1				
I. catus (fingerlings)	19	.2								
A. n. marmoratus			38	23.4	21	12.6	32	8.8	12	5.1
A. n. m. (fingerlings)	159	.5	146	.1					1,130	8.9
A. n. erebennus	6									
A. bostoniensis	56	.4	204	1.1	42	.2	6	.7	7	.2
E. americanus			6		4	.3	16	2.8		
E. niger			1							
F. chrysotus			6		356	.4				
G. a. holbrookii			4							
H. formosa	7,130	2.2	2		1					
A. sayanus	5		8	.1	4	.1				
C. coronarius	86	3.8	915	16.5	663	6.3	401	17.7	14	1.4
C. c. (fingerlings)									1,226	4.6
P. annularis			32	.3	29	1.7	5	.9	502	3.2
P. nigro-maculatus			3							
C. macropterus					4				6	.3
E. gloriosus	23,321	19.8	966	2.1	1,988	2.3			254	1.1
L. m. purpurescens			2,095	52.1	261	6.8	404	34.4	38	.4
L. m. microlophus	124	1.1	305	13.8	740	12.0			129	1.7
L. auritus	117	.3	234	9.2	1					
Misc. sunfishes			159	8.1	19,318	24.2	35,755	63.4	253	.3
H. salmoides			41	11.3	32	7.1				
H. s. (fingerlings)			989	.9	103	.2				
E. everglades			4							
L. s. vanhyningi										
M. undulatus										
M. cephalus										
G. shufeldti	160	.55	76	.5						
H. barratti	394	.3	101	.1	14	.1			14	
T. m. fasciatus			6	.1						
P. lethostigmus	1	.6	1	.1						
P. l. (small)									4	2.6
Total	39,753	158.4	8,079	172.6	23,871	153.4	51,973	212.8	7,720	123.5

in the number of small sunfish was probably due to the cover provided. The fact that fish numbers increased during the third season of spraying strongly suggests that such applications had little, if any, influence on the fish population of such waters.

Population estimates were not made in pond 2, and gross observations were discontinued after the seventh treatment because of the great increase in sawgrass. During the first seven treatments, the

Table 3c. *Effects on fish populations of the routine airplane application of DDT sprays and thermal aerosols at 0.1 pound per acre over a 1- to 3-year period as indicated by fish population studies in 1-acre areas in check and treated ponds at the Savannah River Migratory Waterfowl Refuge before treatment and at the end of each season's operations in 1946, 1947, and 1948*

Species taken	Pond 3-Aerosol		Pond 4 check					
	1946		1946		1947		1948	
	After treatment		After treatment		After treatment		After treatment	
	Number	Weight	Number	Weight	Number	Weight	Number	Weight
		Pounds		*Pounds*		*Pounds*		*Pounds*
L. platyrhincus	1	3.2	1	3.6	17	23.1	11	6.8
A. calva	3	10.4						
P. pseudoharengus								
D. cepedianum	1,898	100.3	372	23.2				
B. tyrannus								
A. mitchilli								
E. s. sucetta	190	20.9					13	.1
C. carpio								
N. c. bosci	489	12.0	84	2.2			342	.8
N. maculatus	1		2					
I. catus			2	1.9				
I. catus (fingerlings)								
A. n. marmoratus	410	27.3	608	20.4	148	24.0	99	21.4
A. n. m. (fingerlings)								
A. n. erebennus							7	2.6
A. bostoniensis			2	.2	5	7.8	14	.2
E. americanus	1						4	.2
E. niger								
F. chrysotus							2,609	2.8
G. a. holbrookii					541	.6	729	.4
H. formosa								
A. sayanus	95	.9	1				3	
C. coronarius	61	5.4	20	2.8	62	.9	1,264	5.0
C. c. (fingerlings)								
Pomoxis annularis	94	1.1	96	1.9	60	6.1	122	1.0
P. nigro-maculatus								
C. macropterus	265	4.0	79	1.8	39	7.3	3	.4
E. gloriosus	2						3,129	5.2
L. m. purpurescens	48	7.6	5	1.8	1	.3		
L. m. microlophus			12	1.5			10	.2
L. auritus	42	6.5	2	.4				
Misc. sunfishes	45	.2			930	3.0	162	.7
H. salmoides	15	8.0	23	2.0			18	.2
H. s. (fingerlings)	34	1.4			16	.2		
E. everglades								
L. s. vanhyningi			2					
M. undulatus								
M. cephalus								
G. shufeldti								
H. barratti							313	.1
T. m. fasciatus								
P. lethostigmus								
P. l. (small)								
Totals	3,694	209.2	1,311	63.7	1,819	73.3	8,852	48.1

following reduction was noted: golden shiners, 11; *Gambusia*, 6; flyer sunfish, 4; white crappie, 4; largemouthed bass, 2; pigmy sunfish, 1; and tadpoles, 2. Pond 2 was not sprayed during 1947 or 1948.

Only a few fish were killed in pond 3, which received 15 thermal aerosol applications in 1946. Two gizzard shad were found after the second application and a flyer sunfish after the seventh treatment. A population assay was not made prior to treatment because the pond had been flooded only the previous January. A poisoning study was made and a satisfactory fish population was found after completion

Figure 2. Collecting dead fish from the area within the barrier seine after poisoning.

of the treatments in September 1946. The area selected for the fish population study averaged from 3 to 4 feet deep and had a moderate stand of waterlillies. The population found in this pond was much larger than that found in the untreated check which had been flooded at the same time (table 3).

Pond 3A received 15 thermal aerosol treatments during the 1946 season and 20 each during the 1947 and 1948 seasons. Only three dead fish were found during the 1946 treatments, these being a largemouthed bass fingerling, a golden shiner, and a largemouthed bass found after the sixth, seventh, and eleventh treatments, respectively. During 1947, 12 sunfish, 36 golden shiners, and 2 frogs were found. Routine examinations were not made during 1948.

The area selected for the fish population studies in pond 3A was some distance from shore (fig. 2) and had water which ranged in depth from 3 to 5 feet. Early in 1946 this area had a moderate stand of *Naias* and some *Ceratophyllum* and *Myriophyllum*.

Vegetation increased considerably in the counting area during the summer of 1946, and it became very dense during 1947. This great increase in submergent vegetation, chiefly *Naias*, is probably the main cause for the much larger number of small fishes taken in the falls of 1946 and 1947. During the summer of 1948, vegetation practically disappeared from the study area. In September 1948, it was found that the more open water forms, such as the gizzard shad and chub

870507—50——3

suckers, had increased in number and weight, but there was a great decrease in the smaller vegetation inhabiting forms, especially the blue-spotted sawfish and the golden shiner.

Although there was some reduction in the weight of fish taken in the fall of 1946, this was probably not significant because there was a considerable increase by the fall of 1947. There was a great increase in the numbers of fish, especially among the golden shiners and blue-spotted sunfish.

The untreated areas 4 and 4A were flooded early in January 1946. These areas were examined at the same time as the treated ponds for the detection of dead fish. In 1946 no dead fish were noted in area 4A, and one golden shiner was found in area 4. During 1947, 47 gizzard shad, 1 golden shiner, and 3 bullheads were found dead in the untreated areas. These routine observations were not made in 1948. Because of the recent filling of the untreated check pond, a pretreatment fish population study was not made in it in 1946. However, post-treatment examinations were made in the falls of 1946, 1947, and 1948 (table 3). Although there was an increase in the fish population in the check during 1947, the standing crop did not approach that found in the treated ponds. This may be due in part to the fact that pond 4 was flooded to a depth of only 18 to 24 inches over much of its area and *Panicum hemitomum* grew densely over much of the pond bottom.

During 1948, vegetation in the population study area increased in density. Waterlilies almost covered the water surface and there was considerable *Naias* under them. Water levels dropped during the 1948 season, and as indicated in table 3, the total weight of fish per acre declined from 73.3 to 48.1 pounds. However, the total numbers of fish increased probably because of the more favorable conditions for small fishes.

Comparative Effects of DDT, DDD, Chlordan, and Toxaphene

In 1946, comparative studies were undertaken to determine effects of routine larviciding on permanent ponds having over 3 feet of water. Each material was tested at three dosages, DDT, DDD, and chlordan at 0.1, 0.05, and 0.025 pound per acre; and Toxaphene at 0.2, 0.1, and 0.05 pound per acre. Each dose was applied to ponds in a given area. The heaviest doses were used on a series of ponds in the Camp Stewart area; the medium doses were applied to a group of ponds in South Carolina along U. S. Highway 17 in the vicinity of Hardeeville, S. C.; and the lightest doses, to four ponds along State Highway 5 north of Hardeeville, S. C. Untreated check ponds were available for each of the series, thus 15 ponds were under treatment and observation. Larvicides were applied at weekly intervals in the form of solutions at the rate of 1 gallon per acre by means of air pressure

hand sprayers equipped with atomizing nozzles. The mist sprays were drifted onto the water surface in about 30-foot swaths, a measured quantity of the solution being applied to each pond in accordance with its area.

Each pond was seined before treatment to gain a qualitative and quantitative idea of the fish population. Post-treatment checks were made weekly 24 to 48 hours after spraying for the detection of fish mortality. A total of 14 applications was made. At the completion of treatment, the ponds were poisoned or seined for the determination of residual populations.

In the Camp Stewart area, pond 1 was treated with DDT at the rate of 0.1 pound per acre. This pond, an old borrow pit, had a maximum depth of over 4 feet and an area of 0.3 acre. Vegetation was abundant and there was considerable organic material on much of the pond bottom. Silt is washed into this pond from a nearby railway overpass fill, with resulting muddiness after rains. No dead fish were found during the course of the treatments, and a satisfactory fish population was found after the completion of treatment. On an acre basis, the population was 2,053 fish weighing 182 pounds (table 4), indicating little or no reduction in numbers due to treatment.

Pond 2, which received routine treatments of 0.1 pound of chlordan per acre, is a roadside borrow pit having an area of 0.17 acre, a maximum depth of nearly 5 feet, and an average depth of about 3 feet. The pond, which is fed by road drainage and is usually cloudy, had a sand and mud bottom which was bare of vegetation. Pretreatment seining disclosed many long-eared sunfish, *Lepomis marginatus*. The first fish mortality was noted after the eleventh treatment, and dead fish were observed after each subsequent treatment. Seining after the fourteenth application indicated a marked reduction in the fish population. At the completion of treatment, this pond had a smaller standing population than pond 1, its population on an acre basis being 8,523 fish weighing about 40 pounds.

Pond 3 was treated with Toxaphene at the rate of 0.2 pound per acre. This pond is a straight-sided borrow pit having a maximum water depth of about 10 feet, an average depth of about 9 feet, and an area of 0.44 acre. It had no rooted aquatic vegetation.

No dead fish were noted after the first treatment. There was an extensive loss after the second treatment. Many dead warmouth bass, bluegills, red-breasted sunfish, long-eared sunfish, and *Gambusia* were seen. No live fish were noted after the second treatment and no dead fish were found after the third examination, indicating that the fish had been eliminated. This was later confirmed by poisoning with rotenone.

After the third treatment, no life of any kind other than an alligator was noted in the pond. The water became very clear so that all parts

Table 4a. *Fish found dead at weekly inspections during the treatment period and alive after the 14th weekly application in ponds routinely treated at dosages of 0.1 or 0.05 pound per acre of the indicated larvicides*

Species of Fish	Dosage and larvicides used								
	0.1 pound per acre								
	DDT			Chlordan			Toxaphene		
	Pond No. 1 0.3 acre			Pond No. 2 0.17 acre			Pond No. 9 1.57 acres		
	Number killed	Alive		Number killed	Alive		Number killed	Alive	
		Number	Weight		Number	Weight		Number	Weight
			Pounds			*Pounds*			*Pounds*
Lepisosteus platyrhincus									
Amia calva									
Erimyzon sucetta sucetta		73	16.1				1		
Cyprinus carpio							1		
Notemigonus crysoleucas bosci		260	12.4				5		
N. maculatus									
Ameiurus nebulosus marmoratus		107	19.6		2	0.8			
A. natalis erebennus		7	1.7				2		
Anguilla bostoniensis		4	1.4		2	0.4	2		
Esox americanus		8	1.5						
Umbra pygmaea		5	0.1						
Fundulus chrysotus									
F. heteroclitus heteroclitus									
F. dispar lineolatus									
Gambusia a. holbrookii		1		2	658	0.7			
Heterandria formosa									
Aphredoderus sayanus		5	0.1						
Chaenobryttus coronarius		2	0.6		7	1.3	21		
Pomoxis annularis							1		
Centrarchus macropterus					2	0.1			
Acantharchus pomotis									
Enneacanthus gloriosus		3	0.1						
E. obesus		2							
Lepomis macrochirus purpurescens							1		
L. m. microlophus									
L. auritus		51	0.9				13		
L. marginatus		5	0.1	7	695	3.4			
L. punctatus punctatus							3		
Miscellaneous sunfishes		83	0.1		83	0.1	51		
Huro salmoides							6		
Elassoma evergladei									
Hololepis barratti							2		
Labidesthes sicculus vanhyningi							18		
Total	0	616	54.7	9	1,449	6.8	126	0	0

of the pond could be seen. This indicated a drastic reduction in the plankton population, and it was some time before it was reestablished.

Pond 4 received routine spray treatments of DDD at 0.1 pound per acre. This pond was a borrow pit having a water area of about 0.84 acre. It had a clay and silt bottom, a maximum depth of about 5 feet, and an average depth of a little less than 3 feet. There were some rooted aquatic plants around the pond edges and the water was fairly clear. During wet periods, the pond had an inlet and outlet and there was considerable flow through it.

The first fish loss was noted at and after the fourteenth treatment. Dead fish found were 2 warmouth bass and 4 redfin pike. Seining previous to and at the completion of treatment indicated a reduction

Table 4b. *Fish found dead at weekly inspections during the treatment period and alive after the 14th weekly application in ponds routinely treated at dosages of 0.1 or 0.05 pound per acre of the indicated larvicides*

Species of fish	Dosage and larvicides used											
	0.05 pound per acre											
	DDT			DDD			Chlordan			Toxaphene		
	Pond No. 7 0.88 acre			Pond No. 8 0.46 acre			Pond No. 10 0.82 acre			Pond No. 12 0.53 acre		
	Number killed	Alive		Number killed	Alive		Number killed	Alive		Number killed	Alive	
		Number	Weight		Number	Weight		Number	Weight		Number	Weight
			Pound			*Pound*			*Pound*			*Pound*
L. platyrhincus					1	4.3		19	7.6			
A. calva								7	11.9			
E. s. sucetta	21	83	4.2		177	25.0		222	27.4		55	11.3
C. carpio												
N. c. boscs								34	0.9			
N. maculatus								6				
A. n. marmoratus					5	1.2		25	5.1		13	0.3
A. n. erebennus		1	1.2		1	0.8		30	3.4		13	3.4
A. bostoniensis		1	2.5		6	1.9		19	1.2		7	0.5
E. americanus	3	5	0.3		30	2.3		20	1.3		3	0.2
Umbra pygmaea								4				
F. chrysotus					11	0.1		40	0.1			
F. h. heteroclitus								36	0.1			
F. dispar lineolatus	1						1				8	
G. a. holbrookii					127	0.2		24		1		
H. formosa								62				
A. sayanus								1				
C. coronarius	4	6	0.1		141	2.3		278	17.5	1	23	0.8
P. annularis	1											
C. macropterus					46	1.3		6	0.5			
A. pomotis		1	0.1					2	0.2			
E. gloriosus		1						73	0.1			
E. obesus					10							
L. m. purpurescens								20	0.6	1		
L. m. microlophus					160	1.0		14	0.6			
L. auritus	5	27	0.5					4	0.3			
L. marginatus	5	7	0.1		21	0.1		6	0.1	2	4	0.1
L. p. punctatus												
Misc. sunfishes					268	0.4		753	0.6		1	0.1
H. salmoides	1							6	6.3	2		
E. evergladei								40				
H. barratti	1				3							
L. s. vanhyningi												
Total	42	132	9.0	0	1,007	40.9	1	1,751	85.8	7	127	16.7

in the fish population. No dead fish were seen in the check pond during the study period.

Pond 7 of the medium dosage series was routinely treated with DDT at a dosage of 0.05 pound per acre. This pond is a straight-sided borrow pit having an area of about 0.88 acre, a maximum depth of 6.5 feet and an average depth of about 5 feet. There was very little aquatic vegetation in the pond, and the water was turbid.

Dead fish were first found in the pond after the third treatment and thereafter following the fifth, eighth, tenth, eleventh, twelfth, thirteenth, and fourteenth treatments (table 4). At the end of treatment, the population in this pond on an acre basis was 150 fish weighing 10.2 pounds, indicating a considerable reduction.

Pond 8 closely resembled pond 7. It was one-fourth mile away, had the same general surroundings, type of banks and bottom, and type of water. It differed only in size and depth, having an area of about 0.46 acre, a maximum depth of 6 feet, and an average depth of 4 to 4½ feet. No dead fish were found in this pond during the period of treatment with DDD at 0.05 pound per acre (table 4). On an acre basis the standing fish population was 2,190 fish weighing 88 pounds. It is inferred that the fish population in this pond was not reduced as much as it was in pond 7, and that DDD is not as toxic to fish as is DDT at comparable dosages.

Pond 9 was routinely treated with Toxaphene at the rate of 0.1 pound per acre. This pond had a rather barren clay bottom and clear water, an area of 1.57 acres, a maximum depth of 6 feet, and an average depth of 3 to 4 feet. Over 100 dead fish were found after the first treatment, and all fish were killed by the first three treatments, as indicated by poisoning the water with rotenone (table 4). At 0.1 pound per acre, Toxaphene is exceedingly harmful to fishlife.

Pond 10 received routine treatments with chlordan at a dosage of 0.05 pound per acre. This pond was richer in flora than the others of the series. It was ringed with *Eleocharis* and had considerable submerged vegetation. It had an area of 0.82 acre, a maximum depth of 5 feet, and an average depth of about 2½ feet. Only one dead fish was found during the period of treatment, a starhead minnow, *Fundulus dispar lineolatus*, which was found after the ninth application. The surviving fish population was 2,128, weighing 104 pounds, per acre, indicating that any reduction in fish numbers due to treatment must have been small. No mortality was noted in the check pond for this series.

During the period of study, no dead fish were found in the untreated pond accompanying the low-dosage series. Pond 11 was routinely treated at the rate of 0.025 pound per acre with chlordan with no noted change in the status of the fish population.

Pond 12 was routinely treated with 0.05 pound of Toxaphene per acre. This is a long narrow pond having an area of 0.53 acre and an average depth of 2½ feet. There was no emergent vegetation, but a narrow-leafed *Potamogeton* covered much of the bottom. Fish were common with the long-eared sunfish being dominant. Bluegills, warmouth bass, spotted sunfish, *Lepomis punctatus punctatus*, the blue-spotted sunfish, *Enneacanthus gloriosus*, and the largemouthed bass were also present.

Dead fish were noted at the time of the fifth treatment (table 4). At the end of treatment half of the pond was poisoned. On an acre basis, the remaining fish population was about 508 fish weighing 65 pounds. Observations, fish seining, and poisoning indicated a considerable reduction of the fish population in this pond. Toxaphene is

believed too toxic to fish for use as a mosquito larvicide where fish are important.

Pond 13 received routine treatments with DDT at 0.025 pound per acre. This pond was a long narrow pit having an area of about 0.76 acre and an average depth of 2½ feet. Surface vegetation was lacking and the water was turbid. In pretreatment seining the following fish were taken: bluegill (*Lepomis macrochirus purpurescens*), redbreast sunfish (*Lepomis auritus*), bluespot sunfish (*Enneacanthus gloriosus*), largemouthed bass (*Huro salmoides*), warmouth bass (*Chaenobryttus coronarius*), redfin pike (*Esox americanus*), gambusia (*Gambusia affinis holbrookii*), chain pickerel (*Esox niger*). No dead fish were noted during the period of the study and seining at the completion of the test indicated no significant population changes.

Pond 14 was routinely treated with DDD at 0.025 pound per acre. This pond had an area of 2 acres, a maximum depth of about 3½ feet, clear water, and abundant submerged aquatic vegetation. Fish were common at the beginning of the study. Three dead fish were found in the after-treatment inspections: a *Gambusia* after the ninth treatment, a redbreasted sunfish, *Lepomis auritus*, and a redfin pike,

Table 5. *Results of the routine application of DDT and DDD at specified dosages to 9 ponds over a period of 18 weeks*

Pond	Treatment	Time of first kill	Dead fishes found	Total kill
1	Check		0	0
2	Check		0	0
3	0.05 pound of DDT per acre.	Seventh week	*Erimyzon sucetta sucetta* 10 *Notropis maculatus* 2 *Ameiurus nebulosus marmoratus* 2 *Esox americanus* 1 *Centrachus macropterus* 1 *Chaenobryttus coronarius* 7	23
4	0.05 pound of DDT per acre.	Seventh week	*Ameiurus nebulosus marmoratus* 1 *Esox americanus* 9 *Chaenobryttus coronarius* 3 *Lepomis macrochirus purpurescens* 3 *Huro salmoides* 6	22
5	0.05 pound of DDD per acre.	Sixth week	*Ameiurus nebulosus marmoratus* 2 *Centrarchus macropterus* 2 *Lepomis macrochirus purpurescens* 1 *Huro salmoides* 2	7
6	0.05 pound of DDD per acre.	Tenth week	*Ameiurus nebulosus marmoratus* 5 *Centrarchus macropterus* 2 *Huro salmoides* 2	9
7	0.075 pound of DDD per acre.	Ninth week	*Ameiurus nebulosus marmoratus* 5 *Esox americanus* 1 *Centrarchus macropterus* 8 *Huro salmoides* 1	15
8	0.10 pound of DDD per acre.	Seventh week	*Ameiurus nebulosus marmoratus* 1 *Esox americanus* 3 *Chaenobryttus coronarius* 3 *Lepomis auritus* 1	8
9	0.10 pound of DDD per acre.	Ninth week	*Ameiurus nebulosos marmoratus* 1 *Centrarchus macropterus* 6 *Huro salmoides* 1	8

Esox americanus, after the twelfth treatment. Post-treatment seining indicated no great change in the fish population. The following fish were taken: largemouthed bass, chub suckers, bluegills, red-breasted sunfish, blue-spotted sunfish, and top minnows.

Further comparisons of the effects of DDT and DDD on fish were carried out in nine ponds during 1947. Two of these were retained as untreated checks, two received routine applications of 0.05 pound of DDT per acre, while the remaining received dosages of 0.05, 0.075, and 0.1 pound of DDD per acre. The period of study and observation extended from August 28, 1947, to March 25, 1948, with the treated ponds receiving 18 applications between August 28 and December 22, 1947. Weekly inspections were made for the detection of dead fish. Larger and earlier losses occurred in the ponds receiving DDT (table 5). DDT treatments at 0.05 pound per acre resulted in greater reductions than those produced by DDD at 0.075 or 0.10 pound per acre. In view of these and other findings, it is concluded that DDT is more toxic to fish than DDD.

Summary and Conclusions

Hand Applications of DDT in Small Ponds

Tests with a number of DDT solvents indicated that some were much more toxic to aquatic organisms than others. Isopropyl alcohol, ethyl alcohol, and acetone were less toxic than kerosene, which in turn was less toxic than No. 2 fuel oil when the application rate was 1 or 2 gallons per acre. Velsicol NR–70 was the most toxic solvent tested. Although DDT-kerosene solutions are somewhat less toxic than DDT-No. 2 fuel oil solutions, these differences are probably not significant enough to justify changes in large-scale operations if applications are at the rate of 1 gallon per acre or less. Routine treatments with 1 gallon per acre of fuel oil alone caused no observed fish harm over a period of 14 weeks.

Stable DDT emulsions were much more toxic to amphibians, fishes, and the larger crustacea than were DDT solutions or dusts; therefore, DDT emulsions are not recommended for larviciding in areas having valuable wildlife. Single applications of DDT solutions applied at dosages of 0.4 pound or more of DDT per acre are toxic to fish and result in mortality 1 to 4 days after treatment. Results similar to these have been reported by Surber (*13*). Single applications of DDT solutions at dosages of 0.1, 0.05, and 0.025 pound per acre, and dusts at 0.1 or 0.2 pound of DDT per acre did not kill fish.

In routine hand applications, DDT dusts at dosages of 0.1 to 0.2 pound per acre had little effect on fishes, and it is believed that DDT dusts can be applied routinely at 0.1 pound per acre with little or no significant harm to aquatic organisms.

Routine application of DDT solutions at a dosage of 0.1 pound of DDT per surface acre generally resulted in serious kills of fish after the tenth application, and with continued use, practically eliminated the fish population in ponds. The type of pond greatly influences the effects of the DDT. In one pond, the first loss was observed after the second treatment, while in another, it was not observed during 14 routine applications. Fish mortality occurred earliest in barren sand bottom ponds and was smallest in clay- or silt-bottom pools having considerable vegetation and organic material on the bottom and which received muddy water after rains. Generally, however, routine weekly treatments applied from the ground at 0.1 pound of DDT per acre are significantly harmful to fish and are not recommended for malaria mosquito control where fish are important. No dead fish were observed in ponds routinely treated with 0.025 pound of DDT per acre.

Routine treatments with solutions at dosages of 0.05 pound of DDT per acre resulted in harm to fish after the third to the eighteenth treatments. Usually the mortality first occurred between the tenth and thirteenth treatments, and increased significantly after the latter. With continued treatment of the total surface area at 0.05 pound of DDT per acre, the fish population in some ponds is drastically reduced. In larger, deeper bodies of water where only the marginal or problem areas are treated, probably no significant harm would result. Even though some does occur, it will be localized, and the total harmful effects will be slight because of the short period of treatment and the limited extent of the areas treated. Furthermore, in the small ponds where losses do occur, fishery values are slight because of the small size and intermittent nature of the ponds. For adequate malaria control, oil solutions applied at doses of 0.05 pound DDT and 1 gallon of solution per acre, or dusts applied at 0.1 pound of DDT per acre, are generally recommended. Aquatic vegetation is not noticeably inhibited by these treatments.

Airplane Application

At equal discharge rates of 0.1 pound per acre, the amount of DDT reaching the water surface during airplane larviciding is about five times as much for sprays as for thermal aerosols. In tests made in four ponds, two being sprayed and two receiving a thermal aerosol, the sprayed ponds received a calculated average of 53 percent and 76 percent, respectively, of the material discharged during 17 and 16 spray applications; whereas the aerosol ponds received a calculated average of 10 percent and 12 percent, respectively, of the amount discharged from the plane during 15 applications.

Observed fish mortality during the first and succeeding 2 years of treatment with DDT sprays and aerosols was not significant. Popula-

tion studies made before treatment and at the close of each year's treatment in untreated and treated areas for 3 years disclosed no significant decrease in the standing population or any unusual change in its composition attributable to treatments. Hess and Keener (*14*) have reported no harmful effects following 1 year's treatment with thermal aerosol in an area of Wheeler Reservoir. From studies made on the consequences of airplane larviciding during the past 3 years, it is concluded that DDT sprays or thermal aerosols can be routinely applied at a dosage of 0.1 pound per acre for 3 years without harm to the fish population.

Toxic Effects of DDT and Other Insecticides

Studies of the effects of DDT and certain other new insecticides indicate that they are all toxic to fishes if used in large doses. With DDT, the type of pond or water in which it is used greatly influences the onset and severity of toxic action on fishes. Vegetation, organic material, type of water, and silt or turbidity are all factors influencing this action. Crabs, crayfish, amphipods, isopods, and *Palaemonetes* are very sensitive to DDT, being considerably more so than fishes. Among the fishes, some of the Centrarchidae are the first to be affected, especially the bluegill, *Lepomis macrochirus purpurescens*, and the flyer, *Centrarchus macropterus*. Several other fishes are affected almost at the same time, among these being the golden shiner, *Notemigonus crysoleucas bosci*, the chub sucker, *Erimyzon sucetta sucetta;* and the black and brown bullheads, *Ameiurus nebulosus marmoratus*, and *Ameiurus nebulosus erebennus*. The blue-spotted sunfish, *Enneacanthus gloriosus*, seems to be quite resistant, while the eel, *Anguilla bostoniensis*, was the most resistant of the fishes studied. Although top minnows were among the first fish to be killed, they continued to be present during the period of treatment and were in evidence when most other fish had been eliminated. A few frogs and snakes were killed by routine treatment at dosages of 0.1 and 0.05 pound of DDT per acre.

At routine dosages of 0.1 pound per acre, DDD, chlordan, and DDT are toxic to fish and will significantly reduce the population of ponds. At dosages of 0.05 pound per acre, DDT appears to be somewhat more toxic than chlordan or DDD. Studies carried on in 1947 indicated that DDD was considerably less toxic to fish than DDT. These three insecticides appear to have no significant effect on the fish population at dosages of 0.025 pound per acre. Toxaphene was found to be very toxic to fishes, giving complete kills at 0.2 and 0.1 pound per acre after two and three applications in deep ponds. Kills were obtained at dosages of less than 1 part in 27 million, indicating that this material is as toxic or more toxic to fish than rotenone and may be useful as a substitute for it in fish management work.

ACKNOWLEDGMENT

The author gratefully acknowledges the assistance of the following members of the staff: William Lynn assisted in all phases of the field work. Willis Mathis gathered data on the effects of airplane dispersion during 1947 and 1948 and directed the small pound studies on a comparison of DDT and DDD in 1947. Harry Stierli, assisted by John Taylor as pilot, was in charge of the airplane dispersion of larvicides. Members of the Chemistry Branch who made DDT determinations were Miss Mary Goette, Sam Resnick, and William Schmitz. Dr. Reeve Bailey, Curator of Fishes, University of Michigan, confirmed fish identifications. Special thanks are extended to Dr. S. W. Simmons who, as Director, made the study possible and actively encouraged and expedited the studies.

REFERENCES

(*1*) A joint statement of policy by the United States Army and the Public Health Service: Use of DDT for mosquito control in the United States. Pub. Health Rep. **60:** 469–470 (1945).

(*2*) Lackey, James B., and Steinle, Mary Louise: Effects of DDT upon some aquatic organisms other than insect larvae. Pub. Health Rep. Supp. No. 186, pp. 80–90 (1945).

(*3*) Tarzwell, Clarence M.: Effects of DDT mosquito larviciding on wildlife. I. The effects on surface organisms of the routine hand application of DDT larvicides for mosquito control. Pub. Health Rep. **62:** 525–554 (1947).

(*4*) Erickson, Arnold B.: Effects of DDT mosquito larviciding on wildlife. II. Effects of routine airplane larviciding on bird and mammal populations. Pub. Health Rep. **62:** 1254–1262 (1947).

(*5*) Bishop, E. L.: Effects of DDT mosquito larviciding on wildlife. III. The effects on the plankton population of routine larviciding with DDT. Pub. Health Rep. **62:** 1263–1268 (1947).

(*6*) Scudder, Harvey I., and Tarzwell, Clarence M.: Effects of DDT mosquito larviciding on wildlife. IV. The effects on terrestrial insect populations of routine DDT larviciding by airplane. Pub. Health Rep. **65:** 71–87 (1950).

(*7*) Eide, P. M., Deonier, C. C., and Burrell, R. W.: The toxicity of DDT to certain forms of aquatic life. J. Economic Ent. **38:** 492–493 (1945).

(*8*) Ginsburg, Joseph M.: Toxicity of DDT to fish. J. Economic Ent. **38:** 274–275 (1945).

(*9*) Tarzwell, Clarence M.: The possibilities of a commercial fishery in the TVA impoundments and its value in solving the sport and rough fish problem. Trans. Am. Fisheries Soc. **73:** 137–157 (1943).

(*10*) Metcalf, R. L., Hess, A. D., Smith, G. E., Jeffrey, G. M., and Ludwig, G. W.: Observations on the use of DDT for the control of *Anopheles quadrimaculatus*. Pub. Health Rep. **60:** 753–774 (1945).

(*11*) Krusé, C. W., and Metcalf, R. L.: An analysis of the design and performance of airplane exhaust generators for the production of DDT aerosols for the control of *Anopheles quadrimaculatus*. Pub. Health Rep. **61:** 1171–1184 (1946).

(*12*) Tarzwell, Clarence M.: Fish populations in the backwaters of Wheeler Reservoir and suggestions for their management. Trans. Am. Fisheries Soc. **71:** 201–214 (1942).

(*13*) Surber, Eugene W.: Effects of DDT on Fish. J. Wildlife Management **10:** 183–194 (1946).

(*14*) Hess, A. D. and Keener, G. G.: Effects of airplane distributed DDT thermal aerosols on fishes and fish food organisms. J. Wildlife Management **11:** 1–10 (1947).

INCIDENCE 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 FEBRUARY 4, 1950

For the current week, major increases are noted in reported cases of communicable diseases for measles (from 4,580 to 6,230), meningococcal meningitis (from 79 to 83), pneumonia (from 2,104 to 2,493), and scarlet fever (from 1,860 to 1,934).

The increase in reported cases of measles occurred in all geographic divisions and ranged from an increase of 13 cases in the Pacific Division to 364 cases in the West North Central. Thirty-four States and the District of Columbia also reported increases ranging from 1 in Rhode Island to 390 cases of measles in North Carolina (from 158 to 548). Michigan reported 1,224 cases, the largest number of cases in any State for the week. However, the total for the current week is lower than the 5-year (1945–49) median, and the cumulative total for the calendar year (23,129) is lower than the corresponding 5-year (1945–49) median of 28,282. During this 5-year period, the highest corresponding cumulative total was 69,293 for 1949.

The increase in reported cases of scarlet fever for the current week over last week is small and the total is well under the 5-year (1945–49) median. The cumulative total for the year is 8,100 cases which is also less than the corresponding 5-year median of 13,144.

Decreases in reported cases for the current week in the Nation are noted in diphtheria (199 to 180), infectious encephalitis (10 to 5), influenza (6,512 to 5,973), poliomyelitis (114 to 106), tularemia (25 to 15), typhoid and paratyphoid fever (50 to 46), and whooping cough (2,888 to 2,570).

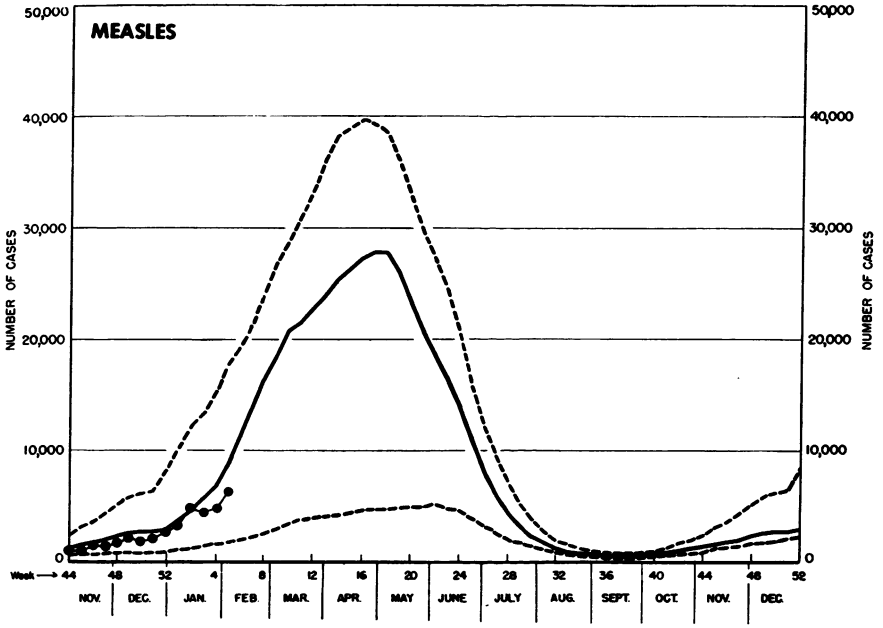
Reported cases of meningococcal meningitis are close to the 5-year (1945–49) median for the week. The total reported to date is 435 which is the same as the median figure for the 1945–49 period. Pennsylvania reported the largest increase, from 2 to 12 cases for the week.

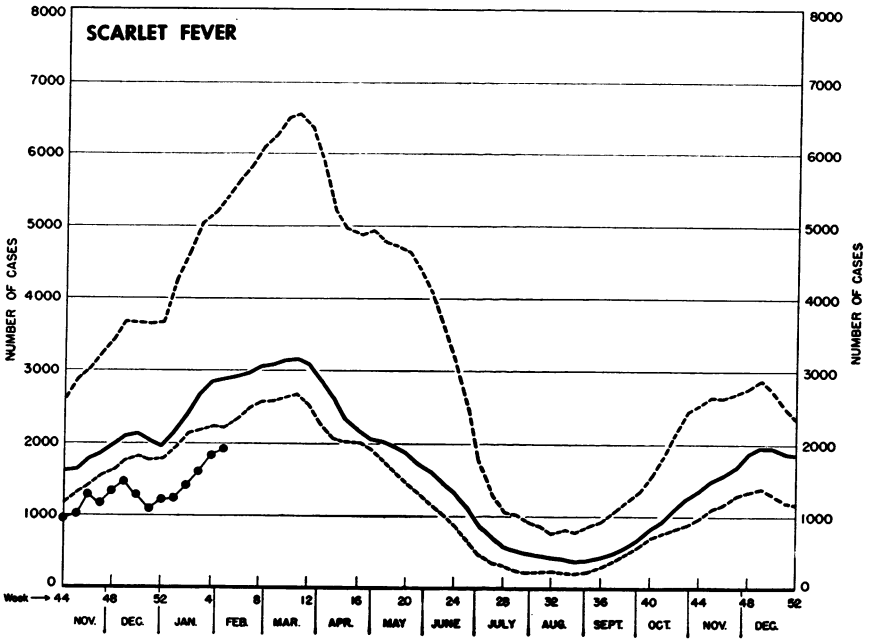
Although reported incidence of influenza decreased for the Nation, the following States showed major increases: Alabama (287 to 556), Arizona (124 to 189), Illinois (1 to 186), Nebraska (0 to 33), Texas (2,831 to 3,114), and Wisconsin (11 to 39). Georgia reported a decrease from 1,400 last week to 349 for the current week.

Two cases of Rocky Mountain spotted fever were reported in Nevada; one case each of smallpox was reported in Missouri and Wisconsin; and one case of psittacosis was reported in Steubenville, Ohio.

Communicable Disease Charts

All reporting States, November 1949 through February 4, 1950





The upper and lower broken lines represent the highest and lowest figures recorded for the corresponding weeks in the five preceding years. The solid line is a median figure for the five preceding years. All three lines have been smoothed by a 3-week moving average. The dots represent numbers of cases reported for the weeks, 1949–50.

Telegraphic case reports from State health officers for week ended February 4, 1950

(Leaders indicate that no cases were reported)

Division and State	Diphtheria	Encephalitis	Influenza	Measles	Meningitis, meningococcal	Pneumonia	Poliomyelitis	Rocky Mountain spotted fever	Scarlet fever	Smallpox	Tularemia	Typhoid and paratyphoid fever	Whooping cough	Rabies in animals
NEW ENGLAND														
Maine				40	1	16			13				38	
New Hampshire				1		1			3				6	
Vermont				3		2			5				27	
Massachusetts	4			145	2				115			1	114	
Rhode Island	1			1		5			7				14	
Connecticut				83	1	59	2		25				87	
MIDDLE ATLANTIC														
New York	11	1	[1] 2	371	6	370	6		[2] 180			2	272	10
New Jersey			5	529	2	65	2		37			6	163	1
Pennsylvania	12			134	12	68	1		118			5	214	
EAST NORTH CENTRAL														
Ohio	7		4	159	1	60	3		244			2	185	2
Indiana	5		12	85		6			60		1		35	[3] 20
Illinois			186	96	6	96	2		87		2	1	107	4
Michigan	3	1	3	1,224	4	73	10		152				213	3
Wisconsin	1		39	205	1	23	1		94	1			139	
WEST NORTH CENTRAL														
Minnesota	2			103	4	9			28			1	17	
Iowa				321	1	1	3		20				7	2
Missouri	5			6	3	3	1		16	1		1	11	
North Dakota		1	12	7					3				6	
South Dakota				26					5				4	
Nebraska	1		33	194	1	12	1		14				7	
Kansas	1			86	1	42			27				9	
SOUTH ATLANTIC														
Delaware				16					1				9	
Maryland	5		4	14	2	33	2		27		1	1	84	
District of Columbia	1			87	1	15			3				4	
Virginia	11		854	18	1	90	2		20			2	42	
West Virginia	3		43	240	1	6	1		20			3	66	6

North Carolina	12			548			4		54		2	3	51	
South Carolina	4		36	85	1	13	1		4				5	8
Georgia	11		349	27		109			26			1	3	12
Florida	2		6	33		11	7		12		1	1	6	
EAST SOUTH CENTRAL														
Kentucky	8		3	24	4	15	4		32		1	1	31	12
Tennessee	6		128	80	4				42		1	2	27	11
Alabama	7		556	60	3	172	2		11			2	54	10
Mississippi	9		13	52	2	37	3		15		2		6	
WEST SOUTH CENTRAL														
Arkansas	7		144	3	1	76			12		1	1	17	[2]
Louisiana	2		7	65	1	39						2	13	
Oklahoma	4		117	13		39	2		17		1	1	25	
Texas	21		3,114	181	10	714	21		56		1	2	179	24
MOUNTAIN														
Montana			13	77		1			22		1	1	3	
Idaho	[1] 1		7	10		7	7		9					
Wyoming				6		2	1		6					
Colorado		1	31	126	1	61	1		13				12	8
New Mexico				11		11			3			1	14	
Arizona	2		189	115		24			17				29	
Utah	1		1	213		8			3				18	
Nevada				1		1		2						
PACIFIC														
Washington	1			72			1		70				40	
Oregon	1		28	29		33	1		24				14	
California	8	1	34	205	5	65	14		162			3	143	
Total	180	5	5,973	6,230	83	2,493	106	2	1,934	2	15	46	2,570	135
Median, 1945–49	302	10	5,170	7,997	85		47		2,970	6	21	48	2,289	
Year to date 5 weeks	899	50	25,450	23,129	435	11,343	584	6	8,100	8	123	201	11,469	661
Median, 1945–49	1,579	32	22,511	28,282	435		248	1	13,144	23	154	205	11,388	
Seasonal low week ends	(27th) July 9		(30th) July 30	(35th) Sept. 3	(37th) Sept. 17		(11th) Mar. 19		(32d) Aug. 13	(35th) Sept. 3		(11th) Mar. 19	(39th) Oct. 1	
Since seasonal low week	5,170		55,980	42,259	1,348		42,066		24,539	15		3,358	33,005	
Median, 1944–45 to 1948–49	9,145		58,781	54,406	1,396		19,203		39,079	77		3,747	35,251	

[1] New York City only. [2] Including cases reported as streptococcal sore throat. [3] Report for 2 weeks.
Psittacosis: 1 case was reported from Stuebenville, Ohio, Feb. 3. Alaska: Influenza 10, measles 1. Hawaii: Influenza 95.

FOREIGN REPORTS

CANADA

Provinces—Notifiable diseases—Week ended January 14, 1950.—Cases of certain notifiable diseases were reported by the Dominion Bureau of Statistics of Canada as follows:

Disease	Newfoundland	Prince Edward Island	Nova Scotia	New Brunswick	Quebec	Ontario	Manitoba	Saskatchewan	Alberta	British Columbia	Total
Chickenpox	1		61	2	416	405	80	58	108	147	1,278
Diphtheria			4	19	19	2					44
Dysentery, bacillary						1				3	4
German measles			7		14	110	18		274	114	537
Influenza			41			23	2				66
Measles			11		336	415	64	97	152	209	1,284
Meningitis, meningococcal			1			3					4
Mumps			92	1	71	549	9	16	80	326	1,144
Poliomyelitis									1		1
Scarlet fever	3		5	4	87	32	13	3	102	6	255
Tuberculosis (all forms)	15		3	10	67	19	17	2	3	86	222
Typhoid and paratyphoid fever					7	1	3			2	13
Undulant fever					3	2					5
Venereal diseases:											
Gonorrhea	7		4	12	84	66	19	25	54	80	351
Syphilis	3		2	2	33	34	6	2	1	13	96
Whooping cough	3		4		142	51		13	1	18	232

JAPAN

Notifiable diseases—5 weeks ended December 31, 1949, and accumulated totals for the year to date.—Certain notifiable diseases have been reported in Japan as follows:

Disease	5 weeks ended Dec. 31, 1949		Total reported for the year to date	
	Cases	Deaths	Cases	Deaths
Anthrax	1		11	
Dengue fever			5	
Diarrhea, infectious	26		770	
Diphtheria	1,771	179	14,835	1,393
Dysentery, unspecified	425	136	23,988	6,937
Encephalitis, Japanese "B"	5	2	1,309	466
Gonorrhea	14,840		181,143	
Influenza	829		2,777	
Leprosy	65		784	
Malaria	85	11	3,732	72
Measles	3,695		165,261	
Meningitis, epidemic	74	20	1,476	436
Paratyphoid fever	123	8	2,219	113
Pneumonia	16,895		139,433	
Poliomyelitis	186		3,133	
Puerperal infection	90		965	
Rabies	8		76	
Scarlet fever	566	4	4,661	63
Smallpox	1	1	124	13
Syphilis	13,947		188,150	
Tetanus	180		2,195	
Trachoma	10,354		176,078	
Tuberculosis	37,130		469,059	
Typhoid fever	467	53	6,488	814
Typhus fever	14		115	6
Whooping cough	10,135		126,632	

NOTE.—The above figures have been adjusted to include delayed and corrected reports.

WORLD DISTRIBUTION OF CHOLERA, PLAGUE, SMALLPOX, TYPHUS FEVER, AND YELLOW FEVER

From consular reports, international health organizations, medical officers of the Public Health Service and other sources. The reports contained in the following tables must not be considered as complete or final as regards either the list of countries included or the figures for the particular countries for which reports are given.

CHOLERA

(Cases)

NOTE.—Since many of the figures in the following tables are from weekly reports, the accumulated totals are for approximate dates.

Place	January–November 1949	December 1949	January 1950—week ended—			
			7	14	21	28
ASIA						
Burma	[1] 252	1				
Bassein	183					
Moulmein	[1] 3	1				
Rangoon	[1] 3					
Ceylon	2					
Trincomalee	2					
China:						
Amoy	[2] 1					
India	90,846	6,599	377	545	116	135
Ahmedabad	1					
Allahabad	17					
Bombay	[3] 6					
Calcutta	[1] 5,282	230	44	42	91	135
Cawnpore	190					
Cocanada	12				2	
Cuddalore	2					
Lucknow	[1] 34					
Madras	433	1		2	1	
Masulipatam	1					
Nagpur	44					
Negapatam	26	3	5	14	19	
New Delhi	[1] 20					
Tuticorin	14				3	
India (French):						
Karikal	55					
Pondicherry	100					
Indochina (French):						
Cambodia	45					
Cochinchina	11					
Pakistan	28,150	[4] 1,127				
Chittagong	75					
Dacca	[5] 101					
Lahore	[1] 24					
Siam (Thailand)	9					
Bangkok	8					

[1] Includes imported cases. [2] Suspected. [3] Imported. [4] Dec. 1–10, 1949. [5] Includes 2 deaths reported as cases.

PLAGUE

(Cases)

(P=present)

AFRICA						
Basutoland	42					
Belgian Congo	16	2				
Costermansville Province	4	2				
Stanleyville Province	[1] 12					
British East Africa:						
Kenya	5					
Tanganyika	15					
Madagascar	124	5		[2] 2		
Tananarive	6					
Rhodesia, Northern	2					
Union of South Africa	[3] 94	6				
Cape Province	[4] [5] 48	[6] [7] 1				
Orange Free State	[8] [9] 14					
Southwest Africa	P	[6] 3				
Transvaal	4					

See footnotes at end of table.

Place	January–November 1949	December 1949	January 1950—week ended— 7	14	21	28
ASIA						
Burma	[10] 460	40				
Mandalay	1					
Moulmein	[10] 6					
Pegu Town		1				
Rangoon	[10] 8					
Yenangyaung Town		1				
China:						
Chahar Province	[11] 69					
Chekiang Province	7					
Wenchow	7					
Fukien Province	20					
Kiangsi Province	9					
India	31,232	[12] 997				
Indochina (French)	128		4		1	
Annam	69		4			
Cambodia	24				1	
Cochinchina	[13] 32					
Laos	3					
Java	651	278				
Jogjakarta Residency	618	277	[14] 17	[14] 9	[14] 19	
Siam (Thailand)	179	4	1			
EUROPE						
Portugal: Azores	5					
SOUTH AMERICA						
Brazil:						
Bahia State	13					
Ceara State	9					
Pernambuco State	19					
Ecuador:						
Loja Province	12	7				
Peru:						
Lambayeque Department	10					
Libertad Department	3					
Lima Department	8					
Piura Department	10					
Tumbes Department	1					
Venezuela:						
Aragua State	2					
OCEANIA						
Hawaii Territory	1					

[1] Includes 2 cases of pneumonic plague. [2] Jan. 11–20, 1950. [3] Includes suspected cases. [4] Includes 16 suspected cases. [5] Includes 8 cases of pneumonic plague. [6] Suspected. [7] Pneumonic plague. [8] Includes 3 suspected cases. [9] Includes 1 case of pneumonic plague. [10] Includes imported cases. [11] Outbreak July–November 1949. First appeared in bubonic form, but later became pneumonic. [12] For week ended Dec. 3, 1949, only. [13] Includes 7 cases of penumonic plague. [14] In Jogjakarta City.

SMALLPOX

(Cases)

(P=present)

AFRICA						
Algeria	276	25				
Angola	748					
Basutoland	1					
Bechuanaland	4					
Belgian Congo	2,040					
British East Africa:						
Kenya	25					
Nyasaland	[1] 1,158	94	5			
Tanganyika	891	33	2			
Uganda	40					
Cameroon (British)	24					
Cameroon (French)	70					
Dahomey	[1] 429	7		12	21	
Egypt	4					
Eritrea	1					
Ethiopia	12					
French Equatorial Africa	411	1				
French Guinea	1					
French West Africa: Haute Volta	121			2		

See footnotes at end of table.

Place	January–November 1949	December 1949	January 1950—week ended— 7	14	21	28
AFRICA—continued						
Gambia	58					
Gold Coast	53					
Ivory Coast	339	17		8	23	
Liberia	3					
Morocco (French)	11	6				
Morocco (International Zone)	2					
Morocco (Spanish Zone)	3					
Mozambique	334	34				
Nigeria	8,507	[2] 57		[2] 9		
Niger Territory	760	129		33		
Portuguese Guinea	1					
Rhodesia:						
Northern	[•] 11	11				
Southern	769					
Senegal	16					
Sierra Leone	114	25				
Sudan (Anglo-Egyptian)	[3] 243	15	1	1	[4] 1	
Sudan (French)	159			1		
Togo (French)	148	7				
Tunisia	1					
Union of South Africa	1,318	30	P			
ASIA						
Afghanistan	241					
Arabia	[3] 83	[3] 201	65	30		
Bahrein Islands	64	4	1	1	1	
Burma	[3] 1,992	413	89	135	79	
Ceylon	[4] 2					
China	976	16				
India	66,463	[5] 868	296	362	425	
India (French): **Yanaon**	1					
India (Portuguese)	224					
Indochina (French)	2,529	220	16	16	21	
Iran	371	98				
Iraq	610	139	[3] 9	14	11	2
Israel	5					
Japan	123	1				
Korea (Southern)	8,948	3				
Lebanon	[3] 143	2				
Malay States (Federated)	46					
Manchuria: **Port Arthur**	9					
Netherlands Indies:						
Java	12,769	132	43	45	81	
Riouw Archipelago	2					
Sumatra	[3] 218	7		2		
Pakistan	4,002	198	18	7	11	
Palestine	188					
Philippine Islands:						
Mindoro Island	11					
Romblon Island	[4] 4					
Tablas Island	2					
Portuguese Timor	4					
Siam (Thailand)	103	7	83	130		
Straits Settlements: **Singapore**	[3] 2					
Syria	627	41	2		1	
Transjordan	196	3		17		
Turkey. (See Turkey in Europe.)						
EUROPE						
Belgium	1					
Germany (U. S. Zone)	3					
Great Britain: England and Wales	[3] 22					
Italy	[6] 99					
Portugal	7	1				
Spain	3					
Canary Islands	6					
Turkey	92					
NORTH AMERICA						
Cuba: **Habana**	[3] 6					
Guatemala	4					
Mexico	759	1				

See footnotes at end of table.

Place	January–November 1949	December 1949	January 1950—week ended— 7	14	21	28
SOUTH AMERICA						
Argentina	349	40	9			
Bolivia	35					
Brazil	352	19	2	[7] 2		
Chile	2					
Colombia	2,615	10				
Ecuador	660	3				
Paraguay	12					
Peru	[1] 3,769					
Uruguay	2	[7] 8				
Venezuela	2,335	4		1		
OCEANIA						
Guam	2					

[1] Corrected figure. [2] In the port of Lagos. [3] Includes imported cases. [4] Imported. [5] For week ended Dec. 3, 1949, only. [6] Includes 95 cases of varioloid reported in Rome Jan. 1–June 10, 1949. [7] Nov. 27–Dec. 17, 1949.

TYPHUS FEVER*

(Cases)

(P=present)

AFRICA						
Algeria	86	9				
Basutoland	27					
Belgian Congo	[1] 42					
British East Africa:						
Kenya	76					
Nyasaland	4					
Tanganyika	2	[2] 1				
Egypt	182					
Eritrea	74	7	2			
Ethiopia	647					
Gold Coast	[3] 6					
Libya	186	11	2			
Cyrenaica	20	2	[4] 2			
Tripolitania	166	9				
Madagascar: **Tananarive**	[4] 10					
Morocco (French)	19	1		[5] 1		
Morocco (Spanish)	[3] 46					
Sierra Leone	[1] 2					
Tunisia	[3] 72	[1 6] 1				
Union of South Africa	187	3	P			
ASIA						
Afghanistan	1,595					
Arabia: **Aden**	[7] 2					
Burma	5					
Ceylon: **Colombo**	[1] 6					
China	59	5				
India	237					
India (Portuguese)	72					
Indochina (French)	21	3				
Iran	174	11				
Iraq	88	18	3		3	1
Japan	102	13				
Korea (Southern)	[3] 1,182	3				
Lebanon	[3] 4					
Pakistan	593	36		2	2	
Palestine	114					
Philippine Islands: **Manila**	[1] 1					
Straits Settlements: **Singapore**	[3] 5					
Syria	[3] 27	3		1		
Transjordan	63	6	2			
Turkey. (See Turkey in Europe.)						

See footnotes at end of table.

Place	January–November 1949	December 1949	January 1950—week ended— 7	14	21	28
EUROPE						
Belgium	[3] 7 5					
Bulgaria	393					
Czechoslovakia	22					
France	5					
Great Britain:						
England and Wales	[1] 7 4					
Malta and Gozo	[1] 30	1				
Greece	71	2				
Hungary	20					
Italy	[3] 27					
Sicily	28					
Poland	341					
Portugal	6					
Rumania	417					
Spain	7	1				
Turkey	211	28	7	8	3	2
Yugoslavia	207	13				
NORTH AMERICA						
Bahama Islands: Nassau	[1] 1					
Costa Rica [1]	51					
Cuba [1]	[8] 4					
Guatemala	50					
Jamaica [1]	19					
Mexico	[3] 234	12		[1] 2		
Panama Canal Zone [1]	12					
Panama (Republic)	[1] 5					
Puerto Rico [1]	44					
SOUTH AMERICA						
Argentina	[1] 2					
Bolivia	53					
Brazil	[3] 6					
Chile	[3] 359	17	2			
Colombia	[3] 2, 505					
Curacao	[1] 5					
Ecuador	[3] 330					
Peru	1, 103					
Venezuela	[3] 120					
OCEANIA						
Australia [1]	125	8	1			
Hawaii Territory [1]	[8] 16	1				

*Reports from some areas are probably murine type, while others include both murine and louse-borne types.

[1] Murine type. [2] In Dar es Salaam. [3] Includes murine type. [4] Suspected. [5] Jan. 1–10, 1950. [6] In Tunis. [7] Includes imported cases. [8] Corrected figure.

YELLOW FEVER

(C=cases; D=deaths)

AFRICA							
Belgian Congo:							
Stanleyville Province	D	5					
French Equatorial Africa:							
Bangui	D	1					
Gold Coast	C	26		1			
Accra	D	1					
Ankobra Ferry	D			[1] 1			
Birim District	C	[2] 3					
Komenda Village [3]	D	1					
Nkwanta Dunkwa Area	D	1					
Oda Area:							
Akwatia	C	[4] 5					
Atiankama	C	[5] 1					
Bawdua	C	[5] 3					
Esuboni	C	[5] 3					
Oseikrome Village	D	1					
Winneba Area:							
Apam	D	1					
Akukuom	D	1					
Nyakrom	C	[6] 5					

See footnotes at end of table.

Place		January–November 1949	December 1949	January 1950—week ended— 7	14	21	28
AFRICA—continued							
Nigeria:							
Kaduna	D	1					
Lagos	D	[7] 2					
Sierra Leone:							
Freetown	D		[7] 1				
Koinadugu District	C		[8] 1				
Sudan (French):							
Bamako	D	[5] 1					
NORTH AMERICA							
Panama:							
Colon Province	D	3					
Pacora	C	[9] 8					
SOUTH AMERICA							
Bolivia:							
Chiquisaca Department	C						[10] 30
Brazil:							
Acre Territory	D	1					
Amazonas State	D	1					
Para State	D	3					
Ecuador:							
Napo Pastaza Province	D	1					
Peru:							
Cuzco Department	D	3	*				
San Martin Department	D	1					

[1] Onset Jan. 1, 1950; died Jan. 5, 1950, at hospital in Bogoso. [2] Includes 2 suspected cases. [3] Near seaport of Sekondi. [4] Includes 1 suspected case. [5] Suspected. [6] Includes 2 suspected cases (1 fatal), and 3 fatal confirmed cases. [7] Imported. [8] Confirmed. [9] Reported Jan. 15, 1949. Date of occurrence Nov. 11–Dec. 30, 1948; 5 cases (all fatal) confirmed, 3 nonfatal suspected cases. [10] Information dated Feb. 2, 1950: Outbreak reported in districts of Monteagudo Muyupampa, and Rio Azero, Chiquisaca Department, Bolivia. 12 deaths reported with the above 30 cases.

DEATHS DURING WEEK ENDED FEBRUARY 4, 1950

	Week ended Feb. 4, 1950	Corresponding week, 1949
Data for 94 large cities of the United States:		
Total deaths	9,282	9,838
Median for 3 prior years	9,838	
Total deaths, first 5 weeks of year	48,324	49,952
Deaths under 1 year of age	632	734
Median for 3 prior years	754	
Deaths under 1 year of age, first 5 weeks of year	3,159	3,479
Data from industrial insurance companies:		
Policies in force	69,855,244	70,633,498
Number of death claims	14,846	14,328
Death claims for 1,000 policies in force, annual rate	11.1	10.6
Death claims per 1,000 policies, first 5 weeks of year, annual rate	10.2	9.8