COMPARISON OF INSECTICIDE RESIDUES FROM TWO MISSISSIPPI OXBOW LAKES

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ABSTRACT

Monthly insecticide tests on waters from two Yazoo-Mississippi Delta Oxbow Lakes show DDT levels to be highest in winter and spring months.

Comparison of insecticide levels in Wolf Lake and Mossy Lake waters, muds, and fish flesh show consistantly higher levels in Wolf Lake.

Thirty-six hour bluegill bioassays in endrin show TLm value of Wolf Lake fish twenty fold greater than Mossy Lake fish.

Two hundred thousand largemouth bass (*Micropterus salmoides*) fingerlings placed in Wolf Lake May 16-25, 1968 showed no survival upon repeated checks with ¼″ mesh seine, electrical fish shocker, and two one-acre population studies.

Monthly comparisons of pH, D. O., Free CO_2, total hardness, methyl orange alkalinity, nitrate nitrogen, ortho-phosphate, plankton counts, and benthic samples failed to account for the decline in carnivorous fish species in Wolf Lake and the inability to re-establish a largemouth bass population.

Modern farm practices and drainage patterns, which make a virtual agricultural sump of many Yazoo-Mississippi Delta Lakes, have made them void of fish at the top of the food chain and prevents re-establishment of largemouth bass populations.

INTRODUCTION

Thousands of acres of lakewater in the Mississippi Delta (Yazoo-Mississippi Flood Plain) that furnished excellent game fishing in the past years no longer produces sufficient creel to interest fishermen. Many causes for the decline in creel have been advanced but with no scientific data to substantiate claims.

The Fisheries Division of the Mississippi Game and Fish Commission has undertaken the collection of environmental data that will help to isolate the cause and/or causes of the decline in productivity of the waters.

Most all the Delta waters have experienced similar major environmental changes during the past twenty years (the period of decline in fish production). Lands have been cleared, intensive and extensive chemical farming practices introduced and followed, and lowlands drained and drainage systems established that no longer allow annual flooding.

A representative lake, Wolf Lake, that has experienced a decline in productivity was chosen for study. Another lake in the Delta, Mossy Lake, that still supplies good fishing but has contrasting physical characteristics was chosen for comparison.

Wolf Lake is located ten miles west of Yazoo City in Humphreys and Yazoo Counties. It is approximately twenty miles in length and receives the drainage from all surrounding farm lands. It has 720 surface acres of water that averages approximately fifteen feet in depth midway between banks. Banks drop off sharply and there is little shallow water. There is very little aquatic weed growth in Wolf Lake. Over 95% of the bordering land is intensively farmed with the major crop being cotton. Flood waters from the Yazoo River, that annually flooded Wolf Lake in past years, have been channeled and the lake now receives only run-off water from its own basin.

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Mossy Lake is located three miles southwest of Morgan City in Leflore County. It is approximately three miles in length with 225 surface acres. It averages approximately eight feet in depth midway between banks. Banks slope gently and much of the water is shallow. Aquatic weed growth is abundant with Coontail, *Ceratophyllum demersum*, being the dominant species.

Most of the farm land surrounding Mossy Lake is used for soybeans. Drainage of much of the land planted with cotton is away from the lake. Though the rise in water level produced by backwaters of the Yazoo River is not as predominant as in past years, it still occurs to some extent.

This project consisted of a collection and comparison of benthic fauna, plankton, chemical characteristics, food habits and residual insecticide levels data from Wolf and Mossy Lakes. This paper is a report on the insecticide levels on the two lakes.

METHODS AND MATERIALS—INSECTICIDES

Five stations on Wolf Lake and three stations on Mossy Lake were arbitrarily established after an aerial flight to determine drainage patterns.

Water samples were collected at approximately two week intervals from surface and bottom levels. Surface water was collected in ½ gallon, small mouth jugs that were pre-washed with redistilled acetone, followed by redistilled hexane. Bottom level water was collected in a stainless steel sewage sampler that had received identical treatment to the jugs. The bottom level water was immediately transferred to the ½ gallon jugs upon surfacing. An amount of water, slightly in excess of one liter, was collected in the field and adjusted to precisely one liter at the laboratory.

The water was extracted with a hexane-pet. ether mix (85-15%) for one hour in the jugs on a mechanical roller. The extract was removed from the water by transferring to separatory funnels and separating. The water was re-extracted twice with 25 mils. of the hexane-pet. ether mix and the extract combined. The extract was then washed with 20 mils. of pet. ether through 2″ of anhydrous sodium sulfate that was pre-washed with 20 mils. of redistilled hexane. Extracts were collected in 250 mil. Kuderna-Danish evaporators and condensed to 7 to 9 mils. over a steam bath. They were then quantitatively transferred to 15 mils. graduated centrifuge tubes and evaporated precisely to 5 mils. with dry air.

Samples were chromatogrammed on a Micro-Tek 220 GLC equipped with electron capture detectors. Identification of insecticides was accomplished via multiple column (3% DC-200 on 100/120 mesh Chrom-Q and 9% QF-1 on 100/120 mesh Gas Chrom-Q), partition coefficients, and survey of farmers and crop dusters of the area to determine insecticides being used. Quantitation was on the basis of purified standards received from:

Chemagro Corporation
Kansas City, Missouri

Shell Chemical Company
New York, New York

Velsicol Chemical Corp.
Chicago, Illinois

Mobil Chemical Company
Ashland, Virginia

Union Carbide Corporation
New York, New York

American Cyanamid Company
Princeton, New York

Dupont Company
Wilmington, Delaware

Agricultural Research Laboratory
Gulfport, Mississippi

Sediment samples were taken by scooping the top centimeter from bottom muds taken with an Ekman dredge. Five dredge loads were used as a representative sample. Samples were allowed to settle overnight and the excess water poured off. Samples were then placed on a paint shaker for a two minute period. A 100 grams subsample was taken for analysis and another 100 grams for drying.

Sediments were extracted with a hexane-isopropyl alcohol, (150-50 mils.), mix after addition of 85 grams anhydrous sodium sulfate. They were extracted on mechanical rollers for a period of 4 hours. The extracts were then filtered through Whatman No. 40 filter paper into 500 mil. separatory funnels. They were then washed three times with volumes of water approximately equal to the volumes of extracts. Ten grams of anyhdrous sodium sulfate and 2.5 grams of celite were added and the extracts filtered through 2″ of sodium sulfate. No further cleanup was required and samples were chromatogrammed as described for water samples. Calculations was on the basis of 150 mils. hexane and no recovery factor was used.

Toxaphene did not show on these samples so they were subsampled, composited, florisiled, and concentrated by a factor of five. They were rechromatogrammed and toxaphene concentrations determined.

Fish were collected with small mesh seine and electrical seine. Fish were, either frozen in the field with dry ice, or brought live to the laboratory and placed in a refrigerator freezer. Frozen small fish were prepared by removing the head, vicera, and skin.

Extraction and cleanups were accomplished as per Training Course Manual, Analysis of Pesticides in the Aquatic Environment, U. S. Dept. of Interior, Jan., 1968.

Fish samples were chromatogrammed similar to water samples.

Data for DDT and its metabolites found in water were totaled and the average per lake established for each sampling date it appeared. The averages and variances are shown in Table 1. Toxaphene data were treated in the same manner for the dates that it occurred in samples and is contained in Table 3. Methyl parathion is presented in like manner in Table 2. Table 5 contains similar data for DDT + metabolites found in sediments. Sediment sampling was accomplished only during 1968. Table 6. contains sediment data for toxaphene.

TABLE 1

Mossy Lake Water - p, p′-DDT+METAB.			Wolf Lake Water - p, p′-DDT+METAB.		
Date: 1967	Av. ppb	s2	Date: 1967	Av. ppb	s2
5-25	....	....	5-25	.530	.5673
6-27	.030	.0000	6-27	.090	.0000
7-28	....	....	7-28	.008	.0001
8-24	.020	.0000	8-24	.082	.0001
9-7	....	....	9-7	.082	.0001
9-21	....	....	9-20	.082	.0001
10-11	....	....	10-11	.238	.0675
12-19	.298	.0296	12-19	.430	.0334
Date: 1968			Date: 1968		
2-22	....	....	2-22	.164	.0021
3-7	....	....	3-7	.198	.0677
3-19	.120	.0010	3-19	.371	.0128
4-15	.090	.0038	4-15	.502	.0233
5-1	.092	.0037	5-1	.364	.0132
5-21	.095	.0050	5-21	.463	.0105
6-4	.006	.0001	6-4	.467	.0441
6-18	.020	.0005	6-18	.298	.0312
7-9	....	....	7-9	.142	.0344
7-23	.005	.0001	7-23	.231	.0217
8-6	.005	.0002	8-6	.066	.0037
8-19	....	....	8-19	.026	.0001
9-5	.007	.0001	9-5	.174	.0134
9-17	.125	.0200	9-17	.101	.0162
10-16	.023	.0006	10-16	.089	.0008
12-11	.262	.2165	12-11	.102	.0010

TABLE 2

Mossy Lake Water - Methyl Parathion			Wolf Lake Water - Methyl Parathion		
Date: 1967			Date: 1967		
8-24	....	....	8-24	.016	.0001
9-7	....	....	9-7	.016	.0001
9-20	....	....	9-20	.060	.0001
10-11	....	....	10-11	113.764	47488.5200
Date: 1968			Date: 1968		
9-5	2.700	43.6844	9-5	5.262	128.0253
9-17	.133	.0509	9-17	.265	.0556

TABLE 3

Mossy Lake Water - Toxaphene			Wolf Lake Water - Toxaphene		
Date: 1967	Av. ppb	s2	Date: 1967	Av. ppb	s2
5-25	....	....	5-25	....	....
6-27	....	....	6-27	....	....
7-28	....	....	7-28	.200	.0750
8-24	....	....	8-24	....	....
9-7	....	....	9-7	.500	.0000
9-20	....	....	9-20	.200	.0750
10-11	....	....	10-11	....	....
12-19	....	....	12-19	.997	.5110
Date: 1968			Date: 1968		
4-15	....	....	4-15	1.437	.6290
5-1	....	....	5-1	.598	.6470
5-21	....	....	6-21	.982	.3950
6-4	....	....	6-4	.463	.0960
6-18	....	....	6-18	.472	.6710
7-19	....	....	7-9	.150	.0900
7-23	....	....	7-23	.277	2.6310
9-5	....	....	9-5	2.707	9.6670
9-17	....	....	9-17	.863	3.0930
12-11	.380	.0040	12-11	1.594	.0700

TABLE 4

Mossy Lake Water - Ethyl Parathion			Wolf Lake Water - Ethyl Parathion		
Date: 1967			Date: 1967		
8-24	....	....	8-24	.212	.1941
9-7	....	....	9-7	.016	.0001
10-11	....	....	10-11	.016	.0001

TABLE 5

Mossy Lake Sediment - DDT+METAB.				Wolf Lake Sediment - DDT+METAB.			
Date: 1967		Av. ppb	s2	Date: 1967		Av. ppb	s2
2-7	Wet	.091	.0079	2-7	Wet	.563	.0216
	Dry	.421	.1711		Dry	1.859	.3910
6-4	Wet	.105	.0024	6-4	Wet	.497	.0040
	Dry	.580	.0205		Dry	1.828	.0698
9-3	Wet	.094	.0019	9-3	Wet	.894	.0548
	Dry	.578	.1387		Dry	3.254	2.2632
9-25	Wet	.100	.0026	9-25	Wet	.513	.0457
	Dry	.552	.0360		Dry	2.100	2.2559

TABLE 6

Mossy Lake Sediment - Toxaphene			Wolf Lake Sediment - Toxaphene		
Date: 1968			Date: 1968		
2-7	Wet	.0575	2-7	Wet	.0647
	Dry	.2674		Dry	.2110
6-4	Wet	.0478	6-4	Wet	.0853
	Dry	.2629		Dry	.3107
9-3	Wet	.0562	9-3	Wet	.0644
	Dry	.2992		Dry	.2166
9-25	Wet	.0375	9-25	Wet	.0766
	Dry	.2159		Dry	.2658

RESULTS AND DISCUSSION

DDT and its metabolites, TDE and DDE were found in Wolf Lake on every sampling date. On nine sampling dates none were found in Mossy Lake. The average amounts of DDT and its metabolites are much higher in Wolf Lake, except on two dates, 9-17-68 and 12-11-68. On these dates abnormally high amounts were obtained at one station on Mossy Lake. This station was located at the mouth of a cotton field drainage ditch.

Toxaphene was found in Wolf Lake water on 14 of 23 sampling dates and only one of the 23 in Mossy Lake. The toxaphene level is much higher in Wolf Lake than Mossy Lake.

Methyl parathion appeared in Wolf Lake on six sampling dates with extremely high amounts showing on 10-11-67. The high amount resulted from extremely high readings on one station and moderately high readings on an adjacent station. Methyl parathion appeared only twice on Mossy Lake.

Ethyl parathion appeared in Wolf Lake samples on three occasions in 1967 and none in 1968. It never appeared in Mossy Lake samples.

Both, toxaphene and DDT, reached a peak in April and a low in August on Wolf Lake during 1968. The highest amount of toxaphene found in Wolf Lake occurred 9-5-68, while planes were spraying. As the variance indicates, sampling points were far from uniform in concentration on this date. Toxaphene was not detected on Mossy Lake during 1967.

The general trend for DDT in both lakes was low to medium in February and early March, peaking in the spring months, falling off in the summer and rising again in the fall. This trend is also observed for toxaphene in Wolf Lake.

Sediment samples show Wolf Lake to be much higher in DDT and toxaphene than Mossy Lake.

The flesh of nine bluegill from Mossy Lake averaged 1.013 ppm DDT + metabolites, $s^2 = .4930$. That of eight bluegill from Wolf Lake averaged 5.041 ppm DDT + metabolites, $s^2 = 1.7520$. No other insecticides were found in the fish.

Bluegill bioassays gave LD_{50} of 15 ppb for Mossy Lake vs 300 ppb for Wolf Lake in endrin, 25 ppb DDT for Mossy Lake vs 30 ppb DDT for Wolf Lake, and 20 ppb toxaphene for Mossy Lake vs 100 ppb toxaphene for Wolf Lake.

Two hundred thousand largemouth bass (1-4″ length) were placed in Wolf Lake May 16-25, 1968. None were recovered during bi-weekly seining operations with small mesh seines and several electrical seining operations.

Benthic sampling showed 37.20 organims per sq. ft. on Wolf Lake and 54.56 organims per sq. ft. on Mossy Lake. Oligochaetes contributed 56.6% of the total organisms on Wolf Lake and .06% on Mossy Lake. Small mussels contributed 54.5% of the total organisms on Mossy Lake and 8.9% on Wolf Lake.

The ratio of Mossy Lake zooplankters to Wolf Lake zooplankters changed from .84 in 1967 to 2.34 in 1968. The ratio of Mossy Lake phytoplankters to Wolf Lake phytoplankters was 1.47 in 1967 and 2.27 in 1968.

Differences in insecticide levels between the two lakes could account for both benthic organisms and plankter differences.

CONCLUSION

The high insecticide level in Wolf Lake is primarily responsible for the decline in piscivorous fish production. DDT and toxaphene are having a subtle but drastic effect upon our aquatic environment. Bass and crappie are virtually absent in many waters where they flourished previous to the advent and widespread intensive use of long lived insecticides. Fishes that are found in such waters show a tolerance that reflect the extent to which those waters have been affected by such insecticides. Massive fish kills have been observed to be produced by both, quick kill, and long lived insecticides. Fishes and other lower forms of life have a marvelous reproduction power and potential for reestablishment, if the environment does not remain inhibitive.

Though insecticides are unquestionable necessary to our modern way of life, long lived insecticide residues are causing portions of life to either disappear or evolve to an extent that may render them harmful to mand and other consumers.

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BIBLIOGRAPHY

Bingham, C. Rex. 1966. The Effects of Dual Combinations of Four Commonly-Used Insecticides on Susceptible and Resistant Mosquitofish. Master's Thesis, Mississippi State University.

Bridges, W. R. 1964. Some Effects on Fish of Chemical Control of Forest Insects, Proceedings, Society of American Foresters, Denver, Colorado.

Ferguson, Denzel E. and Bingham, C. Rex. 1966. The Effects of Combinations of Insecticides on Susceptible and Resistant Mosquitofish, Bulletin of Environmental Contamination & Toxicology, Vol. 1, No. 3.

Ferguson, Denzel E. Undated. Characteristics and Significance of Resistance to Insecticides in Fishes, Mississippi State University.

Ferguson, Denzel E. 1967. The Ecological Consequences of Pesticide Resistance in Fishes, Wildlife Management Inst., Washington, D. C.

Ferguson, Denzel E. and Ludke, Larry J. Undated. Insecticide-Resistant Fishes: A Potential Hazard to Consumers, Mississippi State University.

Ferguson, Denzel E. and Bingham, C. Rex. 1966. Endrin Resistance in the Yellow Bullhead, *Ictalurus natalis*, Transactions of the American Fisheries Society, Vol. 95, No. 3.

O'Brien, R. O. 1967. Insecticides Action and Meabolism, Academic Press, Inc., N. Y.

Steel, Robert G. D. and Torrie, James H. 1960. Principles and Procedures of Statistics, McGraw-Hill Book Co., Inc., N. Y., N. Y.

Walker, Charles R. 1968. Assessment of the Significance of Pesticides Residues in the Aquatic Environment, presented at the Agricultural Research Inst., March 15, 1968, Washington, D. C.