EFFECTS OF HEPTACHLOR ON WILDLIFE IN LOUISIANA

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INTRODUCTION

One of the most controversial pesticide programs is the imported fire ant "eradication" program in which heptachlor ($C_{10}H_5Cl_7$) is one of the powerful insecticides used.

The Argentine fire ant (*Solenopsis saevissima richteri*, Forel) was first noticed in the United States about 1918 in the vicinity of Mobile, Alabama. By 1958 it occupied an estimated 27 million acres in the Southeast (George, 1958). Their large mounds interfere with mowing of pastures and hay fields. Their presence makes hand work in fields an unpleasant task because of their painful bite.

In November 1957 the Plant Pest Control Division of the U. S. Department of Agriculture began a cooperative program with State and local units to "eradicate" the imported fire ant. Most of the treatments in Louisiana during the first two years were with two pounds per acre of active heptachlor, a chlorinated hydrocarbon known to be at least 20 times more toxic than DDT (Rosene, 1958).

The chemical is dissolved in a heavy naphtha and impregnated into small dry pellets of clay. Solvents are kept below 10 percent by weight, and the insecticide averages 10 percent by weight in the granules. The granules have a specific gravity of about 1.2 and sink readily to the bottom of water areas. Application is usually by airplane. Treatments were reported to have been reduced to 12½ pounds of the granular form per acre in the fall of 1959.

Shortly after the beginning of the "eradication" program, reports of wildlife mortality began to mount, and concern developed among wildlife officials. At the initiation of the program practically nothing was known of the effects of heptachlor on wildlife; therefore, a limited number of studies were initiated in the Southeast. The School of Forestry at Louisiana State University, partially under contract with U. S. Fish and Wildlife Service, conducted a series of studies to determine some of the effects of heptachlor on wildlife in the state.

Objectives:

The objectives of the study were to:

1. Determine immediate wildlife mortality on treated areas.
2. Determine amount of heptachlor or heptachlor epoxide present in dead animals.
3. Determine amount of heptachlor or heptachlor epoxide present in animals 6 to 12 months after treatment.
4. Determine effects of heptachlor treatments on nesting success of birds.
5. Determine effects of heptachlor treatments on earthworms.
6. Determine effects of heptachlor treatments on woodcock.

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LOCATION OF STUDY AREAS

Major study areas were located west of the Mississippi River in the following parishes: Acadia, St. Landry, West Baton Rouge, Vermilion, Pointe Coupee, and Concordia. Acadia, St. Landry, and Vermilion Parishes are on the Prairie terrace in south-central Louisiana. West Baton Rouge, Pointe Coupee, and Concordia Parishes are located on former overflow lands of the Mississippi River. Major farm crops are pasture, rice, sweet potatoes, cotton, corn, and cane.

WILDLIFE MORTALITY

Widespread wildlife mortality was found on treated areas following spraying operations. Areas in Acadia, St. Landry, West Baton Rouge, and Vermilion Parishes were checked by varying numbers of wildlife workers and students. (Mortality on Acadia and St. Landry areas was reported by Glasgow, 1958.) All areas checked were treated in March, April, and May.

On four farms the following totals were found: 53 mammals including 12 species; 222 birds including 28 species; 22 reptiles including at least eight species; many miscellaneous frogs; and many crayfish (Table I).

Fish found on the four farms and in Grand Bayou canal included over eight species. An average of 45 fish per 100 feet were found in the canal (Table I).

Density of vegetation in fields, in fencerows, and in thickets limited the number of animals found. In Alabama all of 15 coveys of bobwhite quail disappeared from a treated area, and only 17 percent of the total known population was found when the area was searched for mortality (Clawson and Baker, 1959). Studies by Lay (1958), Rosene (1958),

TABLE I

LIST OF ANIMALS FOUND DEAD

Mammals

18 Cottontail Rabbits
1 Swamp Rabbit
11 Rice Rats
4 Cotton Rats
1 Wood Rat
2 Harvest Mice
2 House Mice
2 Skunks
8 Nutria
3 Opossums
1 Unidentified
Raccoons (Reported)

Fish

Green Sunfish
Bluegill
Miscellaneous Minnows
Bullhead Catfish
Carp
Gar
Shad
Crappie

Reptiles and Amphibians

2 Ribbon Snakes
8 Water Snakes (Natrix *spp.*)
2 Common Water Snakes
1 Gray Rat Snake
1 Blue Racer
1 Cottonmouth Moccasin
3 Skinks
1 Chameleon
4 Turtles
Many miscellaneous frogs

Birds

1 Barn Owl
6 Brown Thrashers
2 Cardinals
2 Common Snipe
1 Eastern Towhee
1 Kentucky Warbler
4 Killdeer
1 Lesser Yellow Legs
18 Meadow Larks
4 Mocking Birds
4 Orchard Orioles
1 Painted Bunting
13 Quail
41 Redwing Black Birds
1 Robin
1 Sharp-Shinned Hawk
2 LeConte Sparrows
13 Savannah Sparrows
3 White-throated Sparrows
6 Miscellaneous Sparrows
2 Virginia Rails
3 White-eyed Vireos
4 Yellow-billed Cuckoos
1 Yellow-breasted Chat
4 Unidentifiable groups of feathers
9 Chickens
72 Domestic Ducks
2 Guinea fowl

Crustaceans

Crayfish (heavy mortality)

and Newsom (1958) showed high wildlife mortality in areas in Texas, Georgia, and Louisiana.

CHEMICAL ANALYSES OF COLLECTED SPECIMENS

Animals suspected to have been killed by heptachlor were chemically analyzed at the Patuxent Wildlife Research Center, Laurel, Maryland. The laboratory also analyzed specimens collected from treated areas at various dates after treatment. Specimens were tagged, frozen, packed in dry ice, and shipped by air express to Patuxent.

Method of Analysis

The analysis of chlorinated hydrocarbons is a time-consuming and expensive procedure which has been described by Dr. James B. DeWitt, *et al.* (1960). Tissues that were analyzed included the entire body of small birds, except the feet and feathers. Larger birds and animals were dissected, and samples of muscle, brain, kidney, liver, and heart were analyzed. Tissues were dried under reduced pressure or over sulfuric acid, weighed, ground, and extracted with petroleum ether. Extracts were concentrated in a gentle stream of air, with care being taken to avoid overheating or too rapid evaporation.

Heptachlor extracts were purified by washing with a 2:1 mixture of concentrated and fuming sulfuric acid, and chromatographed according to the method of Gannon and Bigger (1958). Determination of heptachlor was made according to the method of Ordas, *et al.* (1956).

Heptachlor is readily converted into its epoxide (by oxidation), and is stored in this form in animal tissues. When animals die from acute poisoning, the unchanged compound is sometimes found in their tissues. But little or no heptachlor has been found in cases of sub-lethal exposure or in chronic poisoning. It is usually replaced by the epoxide. Storage of heptachlor epoxide varies over wide ranges, but the concentrations in tissues appear to be proportional to the severity of exposure, and to the length of time required for ingestion of a lethal dose (DeWitt, *et al.* 1960).

Results from Gulf States and Patuxent

More than 98 percent of the analyzed birds and animals that were found dead on treated areas in the Gulf States contained dieldrin, heptachlor, or heptachlor epoxide in amounts varying from a trace to over 20 p.p.m. Comparisons of quantities of residues stored in tissues of field specimens with laboratory animals were possible only for the bobwhite quail, at the time of this study. The tissue concentrations were comparable for this species after similar periods of exposure (DeWitt, *et al.* 1960).

The results of feeding experiments at Patuxent showed that there were wide variations between individuals and between species in susceptability to insecticides (DeWitt, *et al.* 1960).

Dr. DeWitt, *et al.* (1960) published a list of analyses for birds and animals from the entire fire ant control area which may be used for further reference.

Analyses of Louisiana Specimens

Analyses showed that heptachlor epoxide was found in 95 percent of 75 wildlife specimens found dead within three weeks after treatment of the areas in Louisiana. Appendix A which lists the results of analyses of individuals shows a wide variation in the accumulations of heptachlor epoxide in each species. For instance, concentrations varied from 9.7 to 90.4 p.p.m. in 17 savannah sparrows examined.

Fish samples indicated that epoxide content increased from 0 on the day of treatment to 6.0 p.p.m. eight days later.

The wide range of specimens plainly shows the non-selectivity and the danger of the chemical.

ANALYSES OF BIRDS AND ANIMALS COLLECTED SIX TO TWELVE MONTHS AFTER TREATMENT

Results of analyses are available for 39 mammals and miscellaneous birds which were shot or found dead on treated areas six to 12 months

after the areas were treated. Also, 45 woodcock were collected and analyzed, but many of the woodcock came from untreated fields. Fifty-nine percent of the miscellaneous samples and 26 percent of the woodcock contained some level of heptachlor epoxide.

Mammals

The mammals were represented by a single rabbit, two combined samples of rabbits, and two opossums. The combined rabbit sample from near Lottie showed 9.1 p.p.m. of heptachlor epoxide in the kidneys, but there was none in the samples from hearts, livers, and spleens. The rabbits collected from Port Allen contained 3.0 p.p.m. in the livers, but none in the kidneys and hearts. The spleens were not analyzed. A single rabbit from the same farm contained no epoxide residues (Appendix B, Table I).

No residues were found in the tissues of an opossum from Cinclare's land near Port Allen, but one from Marchand's, also near Port Allen, contained 8.9 p.p.m. in the spleen. The heart, liver, kidney, and brain did not contain residues.

Miscellaneous Birds

Epoxide residues ranging from a trace to 7.5 p.p.m. were found in 51.7 percent of the miscellaneous birds collected. The remaining 48.3 percent were free from residues (Appendix B, Table I).

Analyses of tissues from two young domestic geese from Whitehall, which died nine months after the area was treated, showed that one contained heptachlor epoxide and the other contained heptachlor. The kidney of the first one contained 44.3 p.p.m. of epoxide, the heart contained 22.8 p.p.m., and the liver contained 4.2 p.p.m., but the brain was free of residues. The only organ of the second goose that contained residues was the liver which had 1.3 p.p.m. of heptachlor. Analysis of a goose which died 10 months after the area was treated showed 2.3 p.p.m. epoxide in the liver and 1.1 p.p.m. in the breast. The heart, kidney, and brain did not contain residues. Two adult geese were killed and sent to the laboratory. One contained 80.0 p.p.m. of epoxide in the kidneys and a trace in the liver, but none in the heart or brain. The other goose which was killed for analysis contained 2.9 p.p.m. epoxide in the liver but none in the other tissues.

A sample of crayfish collected from the Atchafalaya Basin Floodway in St. Martin Parish in the spring of 1959 contained 0.3 p.p.m. of epoxide.

The volume of these data alone is not sufficient to determine patterns which could be considered reliable. But the data showed considerable variation in the amounts of heptachlor and its epoxide present in different specimens. It is likely that there is a difference in tolerance not only in different classes of animals but also in families, species, and individuals. Condition of the animal at the time of exposure probably influences the effects of the toxicant. It is probable that the minimum amounts shown from the analyses approximates the threshold above which most individuals of the particular species could not survive.

Several reports of moderate wildlife mortality were received during the second year after treatment. It was impossible to check these reports because of lack of finances.

Woodcock

An important phase of this study was concerned with the American woodcock (*Philohela minor*). Analyses of 45 woodcock collected from both treated and untreated areas during the winter of 1958 revealed that 27.7 percent of the birds accumulated varying levels of heptachlor epoxide during their short winter stay in Louisiana (Appendix B, Table II). The percentage of birds containing heptachlor epoxide increased from 11.1 percent in December to 55.6 percent in February. Epoxide levels varied from a trace to 3.5 p.p.m.

Although the samples are small, it appears that the birds had little or no exposure to heptachlor prior to the arrival on the wintering grounds, and that approximately 50 percent were carrying residues by the end of the season. Analyses of woodcock collected in the North

during April, May, and June 1958 also showed that the birds contained the insecticide, which must have been picked up during their winter stay in the South.

About 75 percent of the woodcock collected in 1961 had heptachlor residues, and 100 percent of the birds collected in 1962 in the study areas contained heptachlor residues ranging from 0.4 to 6.0 p.p.m. Seventy-two percent of the woodcock collected in West Louisiana contained epoxide.

Heptachlor is quite lethal to woodcock within a range of 100 to 300-plus p.p.m. The LD50 for woodcock has been calculated to be 191.7 p.p.m. (DeWitt, letter). Since heptachlor leaves persistant residues, exposure to small quantities of this material results in accumulation of residues in tissues, and may cause death at any time that tissue storage exceeds a critical value (DeWitt, *et al.* 1960). In the meantime reproduction could be affected by the heptachlor or heptachlor epoxide residues in the tissues.

Because of rigorous weather conditions, the spring migration probably represents the period in a woodcock's life in which it is under the greatest stress. It is probable that mortality from heptachlor or its epoxide is greatest at this time.

NESTING STUDIES

Studies were carried out in order to determine what effect heptachlor had on the nesting success of birds on treated land. Areas were searched thoroughly and each nest was tagged, and records kept on each visit.

The West Baton Rouge area was treated during May, 1958. The nesting studies (Appendix C), showed that out of 70 active nests of 10 species only eight or 11.4 percent were successful (Glasgow, 1958). In 1959 only 33 nests of 10 species were found and 15 (45.4%) were successful. The 1959 study indicated a 34.0 percent increase in nesting success over the 1958 study. However, the percentage of successful nests on the treated area in 1959 was lower than the percentage of successful nests on an untreated area in East Baton Rouge Parish. Of the 20 nests found on the check area 13 (65.0%) were successful (Appendix C). This higher percentage in nesting success occurred despite the fact that the snake population appeared to be higher on the check area. Based on these data nesting success of birds on land treated with heptachlor was lower than success of nesting attempts on untreated land.

EARTHWORMS

A study of the effects of heptachlor on woodcock included periodic counts and analyses of earthworms from treated pastures. The initial study area was located in Acadia Parish where three treated farms and one nontreated farm were selected. The check area was eventually treated also. Earthworm samples for chemical analyses were also collected from Pointe Coupee, West Baton Rouge, Concordia, and St. Landry Parishes.

Soil samples five inches in diameter and four inches deep were collected and examined for earthworms. Samples were collected on a predetermined grid pattern and were distributed evenly throughout the fields. The soil samples were washed through a set of three screens and the number and volume of worms from each sample were recorded.

Dr. Walter J. Harmon of Louisiana Polytechnic Institute identified the earthworms found in the sampling as: *Diplocardia sigularis, Diplocardia* sp., and *Diplocardia riparia.*

Results of Earthworm Counts

Results of counts were not conclusive, but indicated a drop in earthworm numbers which gradually recovered. Generally the earthworm numbers did not seem to be closely correlated with moisture on the treated farms, although moisture usually affects earthworm distribution (Ensminger, 1954), indicating that heptachlor might have influenced the counts.

It is probable that different species of earthworms have different

tolerances for heptachlor. Incomplete tests in the laboratory revealed that worms which came to the surface of treated soil in boxes usually died while those which remained buried survived. Therefore, it is likely that the night crawlers, which come out on the surface, are subject to greater contamination and therefore, greater mortality.

Earthworm Analyses

Forty-one earthworm samples collected at various places and times were chemically analyzed at Patuxent and 32 samples (78 percent) were found to contain heptachlor epoxide (Appendix D). Levels of epoxide varied from a trace to 49.0 p.p.m. The sample carrying 49.0 p.p.m. came from a very heavy clay soil on the Wilkerson land near Port Allen and was collected 18 months after the area had been treated.

Most of the samples contained less than 10.0 p.p.m. but three samples contained 20.0 p.p.m. and over. A woodcock could consume the equivalent of a lethal dose in 15 to 20 days from worms carrying 20 p.p.m. of epoxide (DeWitt, letter).

Reports on heptachlor content were available for 32 of the samples. Nine (28.1%) of the 32 contained heptachlor residues at levels varying from a trace to 1.7 p.p.m. In every case except one, the samples which contained heptachlor also contained heptachlor epoxide.

Analyses of the earthworm samples show that the level of residues did not decrease substantially over an 18-month period. Analyses of woodcock have shown that they had accumulated residues, and doubtlessly most of the residues were picked up through earthworms.

DISCUSSION

The treatment of land with 20 pounds of granular heptachlor (10% active) per acre is hazardous to wildlife both immediately after treatment and for an undetermined length of time following treatment. There has been a high rate of wildlife mortality on treated land in every state where heptachlor has been used (DeWitt, *et al.* 1960). Analyses of dead wildlife specimens from treated areas show that most of the animals have accumulated enough residues to have caused death. Birds and animals collected on treated areas have been found to contain residues two years after treatment, and residue accumulations are expected to continue for several months.

Rabbits suffer high mortality on treated areas immediately after treatment. There is a reduction in raccoons and opossums also. Rats and mice suffer mortality, but there is some indication that cotton rats may be more resistant to heptachlor than most species (DeWitt and George, 1960). There is the possibility that the Norway rat may exhibit some resistance to the toxicant, also.

The mammals which suffer from high mortality repopulate treated areas at varying rates. Although there is no data to verify it, there is a possibility that heptachlor may affect reproduction in mammals as it does in birds.

Immediate mortality on most bird species is high as indicated in this study and as reported from other studies. Chemical analyses of several hundred birds from treated areas all over the Southeast prove that the birds had absorbed or ingested heptachlor. A much higher percentage of ground feeders is eliminated than the tree-top species.

Quail populations are virtually eliminated immediately after and remain depressed into the second year after treatment. By the end of the second year, however, the populations appear to be approaching normal (DeWitt and George, 1960).

Nesting studies show a drastically low percentage of successful nests during the first year after treatment. The following year the nesting success is near normal, but the nesting population shows a reduction. This reduction in breeding birds may be augmented by chronic poisoning resulting from a gradual accumulation of heptachlor residues.

In laboratory studies, adult quail and pheasants, seemingly unaffected by minute amounts of chlorinated hydrocarbons, produced eggs in which fertility was reduced. They produced fewer chicks and a higher percentage of cripples (DeWitt and George, 1960).

Migratory birds which winter in the Southeast may show the effects of minute accumulations in nesting success in the North.

The reduction in numbers of insects which were killed by the insecticide may seriously affect the food supply of some species of birds. The insects which accumulate the residues are a hazard to birds, which in turn may be a hazard to predators which otherwise would not be seriously affected. Earthworms which store heptachlor residues in their bodies become a hazard for woodcock and robins.

Snake populations seem to be seriously depressed by heptachlor, and there is a possibility that rats and mice may be allowed to increase because of the reductions in numbers of snakes which are a major predator upon these rodents.

Populations of other reptiles are adversely affected, also, but they probably do not have the influence on birds and mammals that snakes do.

Many frogs and toads were killed, and occasionally dead ones were found several weeks after treatment of the areas. Frogs and toads are probably a source of heptachlor epoxide for herons and egrets which feed upon them.

Large numbers of crayfish were killed in Louisiana following heptachlor treatments. Contaminated crayfish may constitute a hazard to wildlife and even people.

Studies in Louisiana were made difficult and unpleasant at times because of the lack of cooperation of the personnel of the Plant Pest Control Division, who refused to supply information which would have been helpful to wildlife interests. Dates of treatment, boundaries of treated areas, additional treated areas, and location of proposed treated areas were withheld or given reluctantly.

RECENT DEVELOPMENTS IN THE FIRE ANT PROGRAM

Some land is still treated with heptachlor at the original rate of application. On most areas treated by public agencies, heptachlor is applied in two applications at the rate of one-fourth pound active material per acre. Mortality of birds and mammals was not detected at this rate.

A more recent development is the use of mirex, an attractant containing a poison. Mirex is believed to be relatively harmless to wildlife. About 50 to 75 percent of treatments is with mirex.

Recommendations for the Use of Pesticides

Any program involving a toxicant to be distributed over the landscape should be preceded by scientific study of, first, the need, and second, the direct and indirect effects of the material upon man, domestic animals, wildlife, crops, and soil organisms.

Federal and state legislation is needed to curb questionable pesticide projects and to establish some degree of supervision over approved programs.

DeWitt and George (1960) offered the following excellent recommendations for safeguarding wildlife values during pest control:

"(1) Chemical treatment should be used only when entomological research has proved it to be necessary.

(2) Before pesticides are used, the effects on different kinds of animals and on animals living in different habitats should be known and carefully considered.

(3) Only minimum quantities of chemicals necessary to achieve adequate control of pests should be applied.

(4) Pesticides should not be applied to areas that are any larger than is necessary and the chemicals that are used should be the ones whose effects are no more long-lasting than necessary.

(5) Whenever possible, chemicals should be applied at the seasons of the year when wildlife damage will be least. Some applications of pesticides can be made during the winter season when fewer birds are present in most northern areas than during the spring migration period; also, certain birds are relatively more mobile during the winter season.

(6) Conscientious effort should be made to be sure that pesticides

are applied at no more than the intended rates and that no areas receive double doses.

Although these procedures will help to minimize damage they are not entirely satisfactory for the protection of wildlife."

Instead of using non-specific pesticides which will kill many kinds of animal life, chemicals should be developed which are specific for the particular pest species. Biological control could be the best and safest means of control available. Experiments have shown that biological control can be highly effective.

SUMMARY

In November, 1957 the Plant Pest Control Division of the U. S. Department of Agriculture started a long-range program attempting to eradicate the imported fire ant from approximately 27 million acres in the Southeast. Heptachlor, a highly toxic chlorinated hydrocarbon, was sprayed at the rate of 20 pounds of the granular form (two pounds active chemical) per acre in most Louisiana treatments during the first two years.

Investigations of the effects of heptachlor on wildlife were made in south-central Louisiana during 1958, 1959, and early 1960 because of the widespread wildlife and fish mortality which resulted from the use of heptachlor. Studies on woodcock have continued.

On four farms the following totals were found within three weeks after treatment: 53 mammals including 12 species; 222 birds including 28 species; 22 reptiles including at least eight species; many miscellaneous frogs; and many crayfish. Fish found on the four farms and in Grand Bayou included eight species. It was impossible to check many areas from which heavy mortality was reported.

Dense vegetation and the fact that sick animals and birds seek seclusion limited the number of dead found to what was believed to be a fraction of the total kill.

Ninety-five percent of the dead animals and birds that were analyzed contained some level of heptachlor or heptachlor epoxide. A wide variation in the amount of accumulated residue was exhibited by both individuals and species.

Analyses of birds and animals collected alive from treated areas within 6 to 12 months after the area was treated showed that 59 percent of the specimens had accumulated residues of the toxicant. Also wintering woodcock collected showed an increase in amount of residues and in the percentage of birds containing residues which seemed to be proportionate to the length of time of exposure to treated soil. In 1962, 100 percent of woodcock collected from treated areas contained heptachlor epoxide.

On a study area which was treated in May, 1958, nesting success was 11.4 percent in 1958 and 45.4 percent in 1959. Although the percentage of successful nests was higher the second year, the number of nesting attempts was 32.7 percent lower. On a similar area which was not treated, 65 percent of the nesting attempts were successful in 1959.

Earthworm counts on treated farms showed a decrease in number of worms immediately following treatment of the area. The populations seemed to recover after three to six months.

Seventy-eight percent of earthworm samples contained epoxide at levels ranging from a trace to 49.0 p.p.m. Twenty-eight percent contained heptachlor. Earthworms, therefore, must account for the main source of the residues found in woodcock.

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APPENDIX A

Heptachlor Epoxide Content of Animal Tissues Collected Within Three Weeks After Treatment

Species	Origin	Date Collected	Heptachlor Epoxide
			p.p.m.
MAMMALS			
Rabbit	Abbeville	4/22/59	
Heart			8.3
Liver			15.1
Kidney			20.4
Brain			53.0
Rabbit	Washington	3/20/59	
Heart			0
Liver			25.8
Kidney			31.2
Brain			101.0
Rabbit	Washington	3/20/59	
Heart			0
Liver			7.6
Kidney			26.7
Brain			63.2
Opossum	Abbeville	4/22/59	
Heart			31.3
Liver			31.7
Kidney			0
Brain			14.1
Opossum	Abbeville	4/22/59	
Heart			18.1
Liver			4.8
Kidney			24.5
Brain			24.3
Cotton Rat	Washington	3/20/59	10.2
Cotton Rat	Washington	3/20/59	10.4
Cotton Rat	Washington	3/20/59	19.7
White-footed Mouse	Atchafalaya Levee	2/ 2/59	12.6

Appendix A (Continued)

Species	Origin	Date Collected	Heptachlor Epoxide
			p.p.m.
White-footed Mouse	Washington	3/20/59	24.2
White-footed Mouse	Washington	3/20/59	27.5
White-footed Mouse	Washington	3/20/59	28.5
White-footed Mouse	Washington	3/20/59	26.0
White-footed Mouse	Washington	3/20/59	29.4
White-footed Mouse	Washington	3/20/59	17.7
White-footed Mouse	Washington	3/20/59	16.0
White-footed Mouse	Washington	3/20/59	10.8
Harvest Mouse	Washington	3/20/59	11.6
Harvest Mouse	Washington	3/20/59	10.2
BIRDS			
Eastern Meadow Lark	Washington	3/20/59	11.5
Eastern Meadow Lark	Washington	3/20/59	11.0
Eastern Meadow Lark	Washington	3/21/59	11.7
Eastern Meadow Lark	Washington	3/21/59	2.7
Eastern Meadow Lark	Washington	3/21/59	8.5
Eastern Meadow Lark	Washington	3/21/59	10.0
Eastern Meadow Lark	Washington	3/21/59	11.1
Eastern Meadow Lark	Washington	3/21/59	9.8
Starling	Washington	3/21/59	12.3
Common Snipe	Washington	3/20/59	9.7
Blue Jay	Abbeville	4/22/59	14.3
Savannah Sparrow	Abbeville	4/22/59	0
Savannah Sparrow	Abbeville	4/22/59	11.7
Savannah Sparrow	Abbeville	4/22/59	25.8
Savannah Sparrow	Abbeville	4/22/59	17.9
Savannah Sparrow	Abbeville	4/22/59	33.0
Savannah Sparrow	Abbeville	4/22/59	32.8
Savannah Sparrow	Washington	3/21/59	9.7
Savannah Sparrow	Washington	3/21/59	30.4
Savannah Sparrow	Washington	3/21/59	90.4
Savannah Sparrow	Washington	3/21/59	15.0
Savannah Sparrow	Washington	3/21/59	38.5
Savannah Sparrow	Washington	3/21/59	52.4
Savannah Sparrow	Washington	3/21/59	45.4
Savannah Sparrow	Washington	3/21/59	37.4
Savannah Sparrow	Washington	3/21/59	26.8
Savannah Sparrow	Washington	3/20/59	25.8
Savannah Sparrow	Washington	3/20/59	21.2
White-throated Sparrow	Washington	3/20/59	10.7
White-throated Sparrow	Washington	3/20/59	38.7
White-throated Sparrow	Washington	3/20/59	16.9
Swamp Sparrow	Washington	3/20/59	48.8
Leconte's Sparrow	Washington	3/21/59	40.0
Leconte's Sparrow	Washington	3/21/59	29.7
REPTILES			
Water Snake (*Natrix*)	Abbeville	4/22/59	1.4
Water Snake (*Natrix*)	Abbeville	4/22/59	1.3
Water Snake (2) (*Natrix*)	Abbeville	4/22/59	4.2
Ribbon Snake	Abbeville	4/22/59	0
Ribbon Snake	Abbeville	4/22/59	0
Gray Rat Snake	Washington	3/20/59	
Heart			65.6
Liver			13.5

Appendix A (Continued)

Species	Origin	Date Collected	Heptachlor Epoxide
			p.p.m.
Blue Racer Snake	Washington	3/20/59	
Heart			0
Liver			9.5
Turtle	Abbeville	4/22/59	2.2
Chameleon and Ground Skink	Abbeville	4/22/59	5.0
AMPHIBIANS			
Cricket Frog and Leopard Frog	Abbeville	4/22/59	5.1
Frogs (Miscellaneous)	Abbeville	4/14/59	3.0
Toad (*Bufo*)	Leonville		30.0
Toads	Church Point		3.1
FISH			
Shad and Bluegill	Abbeville	4/14/59	0
Assorted Fish	Abbeville	4/22/59	6.0
Gizzard Shad	Grand Bayou	4/15/59	0.4
Catfish	Concordia		6.6
CRUSTACEANS			
Crayfish	Abbeville	4/22/59	5.6
Crayfish	Abbeville	4/14/59	0.7

APPENDIX B

TABLE I

Heptachlor Epoxide Content of Animal Tissues Collected 6 to 12 Months After Treatment

Species	Origin	Date Collected	Heptachlor Epoxide
			p.p.m.
MAMMALS			
Rabbits	Lottie	12/30/58	
Heart			0
Liver			0
Kidney			9.1
Spleen			0
Rabbits	Port Allen	12/31/58	
Heart			0
Liver			3.0
Kidney			0
Rabbit	Port Allen	12/31/58	
Heart			0
Liver			0
Kidney			0
Opossum	Cinclare	12/13/58	
Heart			0
Liver			0
Kidney			0
Spleen			0
Brain			0
Opossum	Marchand	12/13/58	
Heart			0
Liver			0
Kidney			0
Spleen			8.9
Brain			0

Appendix B — Table I (Continued)

Species	Origin	Date Collected	Heptachlor Epoxide
BIRDS			p.p.m.
Eastern Meadow Lark	Duckworth	12/31/58	0
Eastern Meadow Lark	Marchand	1/ 3/59	0
Eastern Meadow Lark	Whitehall	2/16/59	0
Cowbird	Whitehall	2/16/59	1.9
Cowbird	Whitehall	2/16/59	0
Robin	Whitehall	2/16/59	0
Savannah Sparrow	Duckworth	12/10/58	0
Savannah Sparrow	Duckworth	12/31/58	Trace
Savannah Sparrow	Marchand	1/ 3/59	0
White-throated Sparrow	Whitehall	2/16/59	Trace
Mourning Dove *	Port Allen	7/26/58	Trace
Mourning Dove	Whitehall	2/16/59	0.7
Mourning Dove	Whitehall	2/16/59	0
Mourning Dove Nestling	Whitehall	5/ 1/59	3.3
Mourning Dove	Port Allen	6/19/59	7.5
Mourning Dove Nestling	Port Allen	6/19/59	4.4
Mourning Dove Eggs	Whitehall	5/ 1/59	0
Brown Thrasher Egg	Whitehall	5/ 1/59	0
Killdeer	Duckworth	12/10/58	2.2
Killdeer	Marchand	12/13/58	Trace
Killdeer	Marchand	12/13/58	0
Killdeer	Marchand	12/13/58	0
Killdeer	Marchand	12/13/58	6.1
Killdeer	Marchand	12/13/58	2.4
Killdeer	Cinclare	12/13/58	Trace
Killdeer	Lewis	12/13/58	1.6
Killdeer	Big Alabama	1/15/59	0
Killdeer	Big Alabama	1/15/59	0
Killdeer	Whitehall	3/ 3/59	1.9
Goose (Died)	Whitehall	4/ 8/59	
Heart			22.8
Liver			4.2
Kidney			44.3
Brain			0
Goose (Died)	Whitehall	4/ 8/59	
Heart			0
Liver			1.3 p.p.m. Heptachlor
Kidney			0
Brain			0
Goose	Whitehall	4/ 8/59	
Heart			0
Liver			Trace
Kidney			80.0
Brain			0
Goose (Died)	Whitehall	5/ 1/59	
Heart			0
Liver			2.3
Kidney			0
Brain			0
Breast			1.1
Goose	Whitehall	5/ 1/59	
Heart			0
Liver			2.9
Kidney			0
Brain			0
Breast			0
Crayfish	Atchafalaya Floodway	Spring 59	0.3

* Collected 2 months after treatment.

APPENDIX B

TABLE II

Analysis of Woodcock Collected During the Winter of 1958-59
(Each Analysis Represents One Bird)

Collection Period	Treated or Untreated Area	Heptachlor Epoxide
		p.p.m.
Dec. 13-31, 1958	Tr	Trace
	Tr	0
	Tr	0
	Tr	0
	Tr	0
	Tr	0
	Tr	0
	Un	0
	Un	0
Jan. 1-15, 1959	Tr	0
	Tr	0
	Un	0.9
	Un	0
	Un	0
	Un	0
	Un	0
	Un	0
	Un	0
	Un	0
	Un	0
Jan. 16-31, 1959	Tr	0.3
	Un	0.2
	Un	0
	Un	0
	Un	0
	Un	0
	Un	1.2
	Un	1.1
	Un	3.5
	Un	0
	Un	0
	Un	0
	Un	0
	Un	0
	Un	0
Feb. 1-15, 1959	Tr	0
	Un	0
	Un	0.5
	Un	0.7
	Un	0
	Un	0
	Un	0.4
	Un	0.3
	Un	0.2

APPENDIX C

TABLE I

Nesting Success on Area Treated Spring 1958 and on Check Area

	Total Active Nests	Eggs and Young Disappeared		Eggs and Young Deserted		Accidentally Destroyed		Undetermined		Fledged	
	No.	No.	%	No.	%	No.	%	No.	%	No.	%
1958 (10 Species)	70	25	32.72	33	47.14	4	5.71	—	—	8	11.43
1959 (10 Species)	33	12	36.36	—	—	3	9.09	3	9.09	15	45.45
1959 Check (Redwing)	20	3	15.00	—	—	2	10.00	2	10.00	13	65.00

APPENDIX D

Heptachlor Epoxide Content of Earthworms

Farm	Date	Heptachlor p.p.m.	Heptachlor Epoxide p.p.m.
A. Daugereau	9/28/58	1.6	10.8
	12/18/58	0	8.2
	11/22/58	0	0
	12/20/58	0	2.0
	2/ 9/59	Trace	2.8
	3/14/59	0	1.7
	6/ 1/59	0	4.0
	8/27/59	0	1.6
L. Daugereau	6/ 2/59	0	7.2
	8/27/59	0	0
D. Colligan	12/30/58	0	0
	8/27/59	0	6.8
R. Fruge	12/20/58	0	1.3
	2/ 8/59	0	0
	6/20/59	0	0
Church Point Pooled Samples	9/18/59	—	8.8
	12/19/59	—	4.7
Whitehall	9/28/58	1.7	9.4
	11/21/58	0.3	3.5
	1/ 5/59	1.1	3.9
	2/ 9/59	0	0
	2/ 9/59	0	3.5
	4/10/59	1.0	0.8
	4/10/59	0	0
	6/ 1/59	0.3	2.1
	1/—/60	—	2.0
Lewis	11/ 4/58	0	Trace
	1/ 8/59	0	1.5
	2/ 6/59	0	0
Marrineaux	11/ 4/58	—	Trace
Duckworth	11/ 4/58	0	Trace
	1/11/59	0.5	0
	2/ 6/59	0.3	1.0
	12/20/59	—	5.1
Morrison	4/10/59	0	7.6
	12/19/59	—	11.7
Thistlewaite	3/25/59	0	3.1
	10/30/59	—	25.4
Wilkinson	5/31/59	0	20.0
	11/13/59	—	49.0
	12/21/59	—	8.1