Stoddard, Herbert L. 1931. The bobwhite quail, its habits, preservation and increase. Charles Scribner's Sons, New York. 559 pp.
———— 1958a. Report on "imported" fire ant situation on or near game preserves of the Thomasville (Ga.) Tallahassee (Fla.) region. Mimeographed report, April 10, 1958. 4 pp.
———— 1958b. Memo on "imported fire ant" June 20, 1958. Mimeographed report, 6 pp.
Travis, Bernard V. 1938a. Fire ant problem in the Southeast with special reference to quail. Trans. N. Amer. Wildl. Conf. 3:705-708.
———— 1938b. The fire ant *(Solenopsis* spp.) as a pest of quail. J. Econ. Ent. 31(6):649-652.
U. S. Dept. of Agr., Agr. Res. Service. 1954. The imported fire ant—how to control it. U.S.D.A. Leafl. no. 350.
———— 1958a. Observations on the biology of the imported fire ant. ARS-33-49.
———— 1958b. Facts about the imported fire ant eradication program. 10 pp.
Ward, Henry S., C. H. M. Van Bavel, J. T. Cope, Jr., L. M. Ware, and Herman Bouwer. 1959. Agricultural drought in Alabama. A.P.I. Agric. Exp. Sta. Bul. 316. 53 pp.
Wheeler, Joel. 1958. The fire ant. Fla. Wildl. 11(10):28-29, 40-41.
Wilson, E. O. and J. H. Eads. 1949. A report on the imported fire ant *Solenopsis saevissima* var. *richteri* Forel in Alabama. Special report to Alabama Department of Conservation Director: Mr. Bert E. Thomas, July 16, 1949. 54 pp.

RESIDUES OF HEPTACHLOR EPOXIDE IN WILD ANIMALS

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In the winter of 1957-58, the United States Department of Agriculture, Plant Pest Control Division, started aerial applications of insecticide in Alabama and Georgia to eradicate the imported fire ant *(Solenopsis saevissima richteri* Forel). An estimated 27 million acres in nine southeastern states had populations of this ant when the program began. Heptachlor, one of the more toxic chlorinated hydrocarbons, was the insecticide most frequently used. Studies of DDT, a hydrocarbon of much lower toxicity, had already shown that 3 pounds of DDT per acre caused direct mortality of birds (Mitchell, Blagbrough, VanEtten, 1953), and that 0.5 pound per acre on water drastically reduced aquatic insects (Springer, 1957).

Chlorinated hydrocarbon insecticides are relatively stable compounds. Their insolubility results in soil residues that can be recovered over relatively long periods of time (Young and Rawlins, 1958). Davidow and Radomski (1953) were first to recognize that heptachlor changes to heptachlor epoxide and is stored in animal lipids in that form. More recent papers on the residual amounts of epoxide in soils (Gannon and Bigger, 1958) and on plants (Gannon and Decker, 1958) suggest that wild animals living in an area treated with heptachlor might accumulate the material.

DeWitt, et al. (1960) demonstrated that pesticidal residues in tissues of starlings, rats, pheasants and mallard ducks are "roughly proportional to the degree of exposure," and that "these species differ in their capacity to store residues in tissues."

The present report is based on analyses of 245 animals collected from February 1958 through April 1960, either from areas treated at the rate of 2 pounds of technical heptachlor per acre or from untreated land. Specimens were analyzed for heptachlor epoxide content. Specimens came from treated areas in Decatur County, in southwest Georgia; from

Montgomery and Autauga counties in central Alabama; and from untreated land in Etowah County in northeast Alabama.

Animals were collected by finding dead individuals in a state suitable for analysis and by shooting or trapping. Specimens were analyzed at Patuxent Wildlife Research Center, using the method described by DeWitt, et al. (1960).

Data from bobwhite quail are presented separately and in greater detail than those for other species. Analyses of 159 birds of 33 other species are divided into two groups: those for birds found dead on treated lands 0-30 days after treatment, and those for birds collected on treated and adjacent untreated land 30 days to 3 years after treatment (Table 1). Birds from treated and adjacent untreated land are combined in this second group because the species represented might have moved between different areas, and because many specimens were taken near margins, at points where they could not be realistically assigned to either treated or untreated areas. There is no suggestion in the results that any further data separation is justified.

Findings and Discussion

Dead birds suitable for analysis, found 30 days after areas were treated, totalled 39 (Table 1). This figure excludes the bobwhite quail. Eighty-two percent of these contained heptachlor epoxide. The average amount per bird that contained insecticide was 5.7 mcg/g; the over-all average was 4.7 mcg/g.

The period of 30 days to 3 years after treatment is represented by 120 birds (Table 1). These came from both treated and adjacent untreated land. Sixty-eight percent of the 120 contained residues; the average amount per bird containing residues was 4.3 mcg/g and the over-all average was 2.8 mcg/g.

Table 1 indicates that a wide variation in amount of residue can be expected between individuals of a particular species whether from specimens found dead or collected. This variation between individuals suggests that species may differ in amounts stored (DeWitt, 1960).

All of these factors make it difficult to summarize the data or to draw broad conclusions. The case histories of certain individuals, however, are of particular interest.

The green heron contained 0.8 mcg/g of epoxide. This bird was one of a brood of nestlings that fell from the nest. The parents were never seen visiting the nest or the young after the young fell from the nest. The young remained several days on the ground and finally were found dead.

The bluebird was a male, presumably the same individual that was seen regularly near a nest being checked daily. This bird was found dead 100 feet from the nest. On finding the dead bird, the nest was examined; the young appeared normal. They were alive on the ground beneath the nest the next day, but they died later. The female was not found.

The cedar waxwing is of particular interest because this species is migratory and is found in southern Georgia in winter in compact flocks. This species feeds almost exclusively on fruit and is seldom found on the ground. The two birds were collected from the same flock. Amounts of residue were 7.1 and 1.7 mcg/g.

The one loggerhead shrike found dead on treated land contained only 0.6 mcg/g of epoxide. This bird was found on the very edge of treated land on a public road and may have been killed by an automobile.

The three house sparrows showed a relatively low epoxide content. They were collected at the headquarters of a ranch where approximately 50 acres were left untreated at the edge of about 2,000 treated acres. Birds of this species were frequently seen feeding on treated ground. No house sparrows were found dead, although many were present at ranch buildings.

Meadowlarks found dead on treated land contained an average of 1.5 mcg/g of epoxide. This low level can be partly explained by the fact that three of the 15 birds in the sample were nestlings found dead in the nest. No dead adult meadowlarks could be found near this nest. The three nestling meadowlarks carried no epoxide; they may have died from starvation after one or both parents were killed.

Thirty-eight brown-headed cowbirds were collected on land treated one and two years earlier. Available recoveries from 8,500 cowbirds banded in central Alabama indicate that individuals of this species do not return day after day to feed at the same locality but forage over an area with a radius of at least 15 miles. It is interesting to note that heptachlor epoxide occurred in only 5 of the 28 birds that were analyzed individually.

The purple finch was collected on treated land in Decatur County, Georgia. This species is found there only in winter. It feeds primarily on seeds of trees and shrubs and is seldom found on the ground. This individual, a male, contained 1.8 mcg/g of heptachlor epoxide.

Rufous-sided towhees feed primarily on the ground. The bird analyzed, a female, contained 18.4 mcg/g of heptachlor epoxide; it was collected more than a mile from untreated soil. The area was treated February 6, 1958, 25 months before the towhee was collected. The senior author made regular visits to this location and observed no towhees for a year after the insecticide application.

Not included in Table 1 is a series of 12 specimens collected from untreated land in Etowah County, Alabama. These are of particular interest. Heptachlor had not been used in the vicinity of these collections. An area of approximately 1,000 acres, 12 miles northeast, had been spot-treated, and large areas 105 miles south had been treated by air. Residue content (mcg/g) of the individual specimens from Etowah County was as follows: Four white-throated sparrows, 8.9, 7.9, two negative; two song sparrows, 2.0, one negative; one goldfinch, 4.5; one rusty blackbird, 6.0; one rufoussided townee, a trace; two robins and a vesper sparrow, negative. All species of this group are migratory. Robins and towhees are fund in Etowah County throughout the year as their summer and winter ranges overlap. All other species of this group are present on these areas only in winter.

Residue contents of 41 quail from treated soil are shown in Table 2. Quail are relatively sedentary and this may account for the fact that detectable amounts of epoxide were found in 90 percent of the individuals. All quail found dead contained residues. Adults and juveniles collected 2 to 3 years after treatment from 1,000 to over 3,000 feet from untreated soil contained more than traces of residue. Quail collected near the edge of a treated area contained less residue than those secured well within large treated areas.

Juvenile quail were aged by the method of Petrides and Nestler (1943). Ages of more than 150 days were determined by recapturing individuals that had been marked and aged earlier.

Data for young quail show several interesting points (Table 3). Four birds were approximately 2 or 3 months old when collected from an area treated 5 months earlier. These birds probably had spent their entire lives on freshly treated land. All contained epoxide in amounts from 3.1 to 5.2 mcg/g, averaging 4.1. Ten quail were about 5 to 9 months old when collected from land that had been treated 9 to 11 months earlier. Three of these quail were taken well within the treated area and contained 0, 3.5, and 7.5 mcg/g of epoxide. Seven of the 10 were taken near an edge and were known to move between treated and untreated land; they contained no residue or only traces. More than two years after the area was treated, eight birds were collected well within the treated area. All of them were young of the year, yet every one contained measurable amounts of epoxide. Their average was 1.3 mcg/g.

Epoxide was recovered from a clutch of 12 quail eggs analyzed as two lots of six each. Each analysis showed 1.1 mcg/g of epoxide. The nest from which these eggs came was 1,200 feet inside a treated area. The eggs were collected after the nest was abandoned, which happened 30 days after the area was treated. Considering the embryo development of the eggs, the female probably was on the area before the insecticide was applied and deposited eggs after the application.

Other animals.—The highest amount of epoxide per body weight recovered from any specimen was 172.0 mcg/g from a red-eared turtle (Table 4). This specimen was found dead on the edge of an area that had been treated 279 days earlier. With the exception of a harvest mouse that was trapped near the edge of the treated area and contained 19.2 mcg/g, mammals collected within the treated area contained more

TABLE 1
HEPTACHLOR EPOXIDE IN BIRDS OTHER THAN QUAIL

	Found Dead on Treated Land 0-30 Days After Treatment				*Collected on Treated and Adjacent Untreated Land 30 days to 3 Years After Treatment*			
	No. Analyzed	*Percent Positive*	*H.E. Range mcg/g*	*H.E. Average mcg/g*	*No. Analyzed*	*Percent Positive*	*H.E. Range mcg/g*	*H.E. Average mcg/g*
Green Heron	1	100	....	0.8				
Blue-winged Teal	..	100			1	0	....	0
Killdeer	1	100	....	6.4	2	0	....	0
Mourning Dove					9	78	0–6.4	1.6
Ground Dove					2	100	2.6–6.2	4.4
Screech Owl	1	100	....	6.8				
Y.-shafted Flicker	1	100	....	0.9				
Red bellied Woodpecker					2	50	0–3.9	2.0
Eastern Kingbird	1	100	....	10.9				
Blue Jay					1	100	....	2.3
Brown Thrasher					2	100	3.0–10.	6.5
Robin	3	100	6.1–9.0	7.3	15	87	0–9.3	3.3
Eastern Bluebird	1	100	....	3.2				
Water Pipit					1	100	....	2.3
Cedar Waxwing					2	100	1.7–7.1	4.4
Logerhead Shrike	1	100	....	0.6	1	100	....	6.0
Myrtle Warbler	1	0	....	0				
Yellow-breasted Chat	1	100	....	14.0				
House Sparrow					4	75	0–2.1	1.2
Eastern Meadowlark	15	67	0–8.2	1.5	4	100	4.0–7.9	6.0
Redwinged Blackbird					17	82	0–8.6	2.9
Common Grackle					1	100	....	8.1
Brown-headed Cowbird					28(10)*	18	0–4.7	.5
Cardinal	1	100	.	4.7	3	67	0–4.0	2.0
Purple Finch					1	100	....	1.8
Rufous-sided Towhee					2	100	5.6–18.4	12.0
Savannah Sparrow	1	0	....	0	8	75	0–9.6	3.9

Vesper Sparrow	5	100	5.3–10.3	6.3	3	100	4.0–5.0	4.5
Slate-colored Junco					1	100	....	7.5
Chipping Sparrow	4	100	12.0–15.2	12.8				
Field Sparrow	1	100	....	7.6	1	0	....	0
White-throated Sparrow					8	100	1.9–8.5	5.3
Song Sparrow					1	100	....	2.0
Totals	39	82		4.7**	120	68		2.8**

*Individual analyses 28; the 10 birds shown in parentheses were analyzed in 2 lots of 5; each pool contained 0.4 mcg/g. Pooled birds are excluded from percentage and range.

**Birds containing heptachlor epoxide averaged 5.7 and 4.3 mcg/g, respectively, for those found dead and for those collected.

epoxide than those collected near the edge. Even excluding the turtle, the average amount of epoxide in animals found dead was greater than in animals killed.

SUMMARY

A total of 245 animals, mostly birds, was collected from February 1958 through April 1960, either from areas treated at the rate of 2 pounds technical heptachlor per acre or from untreated land. Specimens were from Decatur County, Georgia; and Montgomery, Autauga, and Etowah Counties Alabama.

Analyses were made at the Patuxent Wildlife Research Center for content of heptachlor epoxide. Content of individuals ranged from 0 to as high as 172.0 mcg/g.

LITERATURE CITED

Davidow, Bernard, and Jack L. Radomski. 1953. Isoliation of an epoxide metabolite from fat tissues of dogs fed heptachlor. Journal of Pharmacology and Experimental Therapeutics, Vol. 107, p. 259-265.

DeWitt, James B., Calvin M. Menzie, Vyto A. Adomaitis and William L. Reichel. 1960. Pecticidal residues in animal tissues. Transactions of the 25th North American Wildlife Conference, p. 277-285.

Gannon, Norman, and J. H. Bigger. 1958. The conversion of aldrin and heptachlor to their exoxides in soil. Journal of Economic Entomology, Vol. 51, No. 1, p. 1-2.

Gannon, Norman, and G. C. Decker. 1958. The conversion of heptachlor to its epoxide on plants. Journal of Economic Entomology, Vol. 51, No. 1, p. 3-7.

Mitchell, Robert T., Harry P. Blagbrough and Robert C. VanEtten. 1953. The effects of DDT upon the survival and growth of nestling songbirds. Journal of Wildlife Management, Vol. 17, No. 1, p. 45-54.

Petrides, George A., and Ralph B. Nestler. 1943. Age determination in juvenile bob-white quail. American Midland Naturalist, Vol. 30, No. 3, p. 774-782.

Springer, Paul F. 1957. DDT: its effects on wildlife. The Passenger Pigeon, Vol. 19, No. 4, p. 156-161.

Young, William R., and W. A. Rawlins. 1958. The persistence of heptachlor in soils. Journal of Economic Entomology, Vol. 51, No. 1, p. 11-18.

TABLE 2.

INDIVIDUAL ANALYSES OF QUAIL OF ALL AGES FROM TREATED AREAS MICROGRAMS OF HEPTACHLOR EPOXIDE PER GRAM OF BODY WEIGHT

Sex and age / *Time after treatment*	*Distance in feet from untreated land* 0-500	501-1000	1001-2000	2001-3000	3001+	?
0-10 days						
Ad. M.			1.0*			
Ad. unknown sex					7.3*, 6.8* 6.0*	
90 days—6 months						
Ad. M.	3.2*					
Juv. M.					3.8*, 3.1*	
Juv. unknown sex			4.4*, 5.2*			
Unknown age, unknown sex					2.1*, 2.4* 3.3*	
7 months—1 year						
Ad. M.		tr.		2.4		
Juv. M.		tr.*, 0, tr., tr.				
Juv. F.	0, 0	tr.	3.5	0		7.5
Unknown age M.					1.1, 1.4, 0	
Unknown age F.		tr., tr.		3.0, 1.9		
2-3 years						
Ad. M.				0.6		
Ad. F.				1.3		
Juv. M.				2.0, 2.0		
Juv. F.			0.5, 0.9	0.7	1.0, 2.2 1.4	

*Found dead. All not starred were collected alive.

TABLE 3.
RESIDUES OF HEPTACHLOR EPOXIDE IN JUVENILE QUAIL FROM TREATED AREAS

Sex	Age in days at collection	Interval between treatment date and collection date	Distance from untreated soil (feet)	Mcg/g of epoxide
?	53	147 days	1,300	4.4
?	55	147 days	1,300	5.2
M	92	146 days	3,300	3.1
M	98	146 days	3,300	3.8
F	224	276 days	1,980	3.5
F	240	320 days	0	0
F	243	329 days	800	tr.
F	251	320 days	2,650	0
M	255	320 days	0	0
M	259	342 days	800	tr.
F	277	320 days	990	0
M	150+	329 days	800	tr.
F	150+	277 days	2,300	7.5
F	150+	329 days	800	tr.
F	150+	25 months	3,300	1.4
F	150+	25 months	3,300	1.0
M	150+	25 months	2,800	2.0
M	150+	25 months	2,800	2.0
F	150+	25 months	2,970	0.7
F	150+	26 months	1,970	0.9
F	150+	26 months	4,950	2.2
F	150+	26 months	1,650	0.5

TABLE 4.
ANALYSIS FOR HEPTACHLOR EPOXIDE OF MAMMALS AND REPTILES FROM AREAS TREATED WITH HEPTACHLOR

Animal	Interval between treatment date and collection date	Distance from untreated soil (feet)	Mcg/g Epoxide
*Harvest mouse (2)	279 days	1,100	5.2
*Harvest mouse (2)	276 days	300	0
*Harvest mouse	277 days	1,500	3.2
*Harvest mouse	277 days	On edge	19.2
**Old-field mouse	17 days	1,320	33.5
*Rice rat	298 days	1,650	6.6
*Cotton rat	278 days	On edge	0
*Cotton rat	279 days	On edge	0.9
**Cotton rat	17 days	1,320	3.6
*Cottontail	322 days	On edge	tr.
*Cottontail	24 months	5,280	2.3
*Cottontail	24 months	5,280	5.0
**Cottontail	17 days	1,650	Liver 20.6; kidney and spleen tr.; brain 9.8; heart tr.; GI tract 5.3; lungs tr.
*Cottontail	284 days	On edge	Liver 0; kidney 0; brain 0; heart 0
*Cottontail	26 months	2,970	Liver 5.9; kidney 0; brain 0; heart 0
**Striped skunk	310 days	2,000	Liver 2.2; kidney 18.7; brain 0; heart 0
**Raccoon	22 months	?	Liver 0; kidney 5.1; brain 0; heart 0
**Raccoon	22 months	?	Liver 10.6; kidney tr.; brain 0; heart 6.0
*Hog-nosed snake	276 days	2,640	2.0
**Hog-nosed snake	20 days	?	4.2
**Red-eared turtle	279 days	On edge	172.0

*Trapped or shot. **Found dead or dying.