Some animals were found to contain more than one insecticide residue. Nearby rice fields were a possible source of the aldrin which was detected in both blackbirds and grackles (*Quiscalus sp.*).

No dead vertebrates were discovered in any of the treated fields or adjacent woods in spite of the fact that many species of mammals, birds, reptiles, and amphibians were observed in these areas.

DISCUSSION AND CONCLUSIONS

No drastic effects on vertebrate populations attributable to insecticides are obvious in the foregoing account, in spite of the fact that the presence of insecticide and insecticide residues was demonstrated in tissues of birds from treated areas. No dead birds were observed during the entire summer nor were any noted behaving in a manner that suggested insecticide sickness. Yet, many birds were observed to forage and feed nestlings on insecticide contaminated food sources. This failure to observe evidence of harmful effects or mortality on an area treated with almost 12 lbs. of insecticide is in sharp contrast to published reports of catastrophic bird kills from single applications of much less insecticide. Such inconsistencies have led us to consider the possibility that some form of resistance may have been developed in bird populations of the treated areas studied here.

Evidence that DDT resistance occurs among vertebrate animals has recently been demonstrated in two species of frogs (*Acris*) and a species of fish (*Gambusia*) living in cotton growing areas of the Mississippi Delta (Boyd, Vinson, and Ferguson, 1962). Dr. L. Ellis (personal communication) reports that bird mortality in cotton growing areas of the Delta now appears markedly reduced compared to that of the mid-1950's. Does all this indicate that insecticides have, through selective mortality, produced bird populations resistant to DDT? A study of this possibility is presently being investigated in both birds and mammals.

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A SYNECOLOGICAL STUDY OF THE EFFECTS OF THE FIRE ANT ERADICATION PROGRAM IN FLORIDA

By ROBERT W. MURRAY

INTRODUCTION

In the spring of 1959 the Florida Game and Fresh Water Fish Commission entered a cooperative agreement with the Florida Agricultural Experiment Station and the Plant Industry Division * of the State Department of Agriculture to carry out a study of the effects of the imported fire ant eradication program. The Experiment Station drew up a research project entitled "A Synecological Study of the Effects of the Fire Ant Eradication Program." During the course of study the Commission was charged with the responsibility

* Formerly State Plant Board.

of conducting mammal and bird studies, the Experiment Station conducted arthropod studies, and the Plant Industry Division applied chemicals to the area selected for treatment.

Three study areas were selected, each approximately 1,280 acres in size. Two of the areas were infested with ants. One of these was treated following preliminary study, while the second area was left untreated. The third area was not infested with ants and remained untreated. Each area served as a control or check against the other. The study was conducted one year prior to treatment and two years following treatment. It was designed to bring out any effect of the fire ants themselves on the populations of animals as well as any population change induced by treatment against the ants. The study was terminated in September, 1962.

Effort was made to select areas having similar types of habitat and land use practices. The two infested areas were in north Okaloosa County and were two miles apart at the nearest proximity. The third area was in north Washington County. The area that was treated was designated as Area 1, the untreated area that had ants was designated as Area 2, and the area with no ants was designated as Area 3.

PROCEDURE

The study began by acquiring aerial photographs of the areas and making basic study maps. These were used to map habitat types and annual land use practices. A general idea of the nature of the land on each area can be gained by referring to Table I.

TABLE I

TABULATION OF LAND USE ON THE STUDY AREAS

Area	*Cultivated*		*Pasture*		*Fallow*		*Timber*	
1959	*Acres*	*%*	*Acres*	*%*	*Acres*	*%*	*Acres*	*%*
1	250	19.30	120	9.27	30	2.32	895	69.10
2	160	12.50	320	25.00	80	6.25	720	56.25
3	490	34.10	340	23.70	70	4.90	535	37.30
1960								
1	230	17.70	148	11.50	22	1.70	895	69.10
2	168	13.10	312	24.50	80	6.25	720	56.25
3	492	34.20	350	24.40	58	4.10	535	37.30
1961								
1	200	15.40	178	13.80	22	1.70	895	69.10
2	160	12.50	320	25.00	80	6.25	720	56.25
3	460	32.00	382	26.60	58	4.10	535	37.30
1962								
1	205	16.00	178	13.80	17	1.30	895	69.10
2	160	12.50	305	23.80	95	7.40	720	56.25
3	448	31.20	384	26.70	68	4.80	535	37.30

Land use practices on the areas varied but little from year to year throughout the study. Timber on the Okaloosa County areas is composed predominately of upland hardwood species, whereas on the Washington County area it is predominately pines and lowland hardwoods.

In studying the bird and mammal populations on the areas, it was decided that some simple means of censusing or sampling populations should be employed that could be repeated throughout the study that would be indicative of population trends. Sampling techniques would need to be such that results could be interpreted in the form of an index to population changes. It was decided that there should be five types of sampling techniques employed: (1) A summer small mammal sampling study. This was to be accomplished by live trapping a given number of traplines on each area. (2) A large mammal sampling study. This was to be accomplished by track counting on dirt roads or fire lanes at regular intervals. (3) A songbird sampling study. This was to be done by traversing a given number of routes on each area by foot at regular intervals and recording the birds heard and seen. (4) A summer quail and dove call count sampling study. This would be accomplished by traveling a given number of roads on each area periodically, stopping at regular intervals, and recording the number of quail "bob-whiting" and the number of doves "cooing". (5) A census of the wintering quail population on each area. This

was to be accomplished by listening at stations for the covey call given by each covey as it leaves the roosting site, approximately 30 minutes before sunrise.

The Agricultural Experiment Station employed the following methods of sampling insect populations: Light traps, alcohol pitfalls, litter samples, sweep net samples, and soil samples. Sampling studies were conducted at monthly intervals.

In September 1960 the Plant Industry Division applied chemicals by airplane to Area 1, using 1.25 pounds of technical heptachlor per acre in granular form. All cropland, pasture, and open timber land was treated. This amounted to approximately 40 percent of the area. At this point the preliminary phase of the study was concluded and the post-treatment phase began. Although the study was designed for only one year of preliminary work, the Commission was able to obtain two years' preliminary data on all sampling studies, with the exception of winter quail censusing and the large mammal sampling study.

SMALL MAMMAL POPULATION SURVEY

Procedure

The plan employed in this survey consisted of live trapping established traplines with Sherman live traps. Traplines were selected in habitats which were reasonably similar on all three areas. All lines were established on a similar pattern, using 50 traps, two at each of 25 stations set 50 feet apart. The only exception to this pattern was in the stream habitat where only 25 traps were used. All lines were numerically designated according to habitat and number of line. The numerical designations of the habitat types selected on each area are as follows:

1. Fallow field (two traplines on each area).
2. Stream (one line on each area).
3. Sparse oak-pine woodland (one line on each area).
4. Cornfield bordering woodland (one line on each area).
5. Fencerow between pasture and road (one line on each area).
6. Fencerow between cornfield and road (one line on each area).

The same traplines were used throughout the study. The pattern for all trapping on each line was based on a set of three consecutive trapping nights. There were, therefore, 150 trap-nights per line on each area (75 trap-nights on habitat 2 on each area) during each year of study.

Bait used for trapping was rolled oats. All animals captured were examined and released. Examination consisted of identification, weight, sex and age determination, reproductive condition, molt, and marking. Marking was by the toe clip method. The study was conducted in 1959 by Mr. Ted T. Allen, graduate student of zoology at the University of Florida; in 1960 by Mr. Donald D. Barbee, undergraduate student of zoology at Florida State University; and in 1961 by Mr. Edwin L. Tyson, post-graduate student of zoology at Florida State University. Trapping was not conducted during 1962 due to conclusive results obtained during the first post-treatment trapping period. Because of the short life span of these animals, it was felt that any effects of the insecticide would have been noted during the first year following treatment.

Results

The most common species captured on the three areas were cotton rat (*Sigmodon hispidus*), cotton mouse (*Peromyscus gossypinus*), old-field mouse (*Peromyscus polionotus*), and house mouse (*Mus musculus*). Species of minor abundance captured were golden mouse (*Peromyscus nutalli*) and rice rat (*Oryzomys palustris*).

A trapping index for each area was formed for the purpose of showing population changes that might occur. This figure is the number of individual animals captured for each 100 applicable trap-nights. It could be calculated for each species per area, or for all species by the following equation: $\frac{X}{\text{No. individuals}} = \frac{100}{150}$. Table II shows the average index figure per area for both the pre- and post-treatment trapping periods.

TABLE II

SMALL MAMMAL DATA FOR EACH TRAPLINE

Area	*Habitat*	*Line*	*Total Captures (All Species)*	*Total Individuals (All Species)*	*Index (All Species)*	*Trap Nights*
Pre-Treatment (Two Years)						
1	1	1	10	7	2.33	300
1	1	2	4	4	1.33	300
1	2	1	15	12	8.00	150
1	3	1	31	18	6.00	300
1	4	1	3	2	0.67	300
1	5	1	16	14	4.67	300
1	6	1	8	6	2.00	300
TOTAL	–	–	87	66	3.38	1,950
Post-Treatment (One Year)						
1	1	1	9	8	5.35	150
1	1	2	1	1	.68	150
1	2	1	3	3	4.00	75
1	3	1	5	5	3.34	150
1	4	1	0	0	0	150
1	5	1	5	3	2.00	150
1	6	1	0	0	0	150
TOTAL	–	–	23	20	2.05	975
Pre-Treatment (Two Years)						
2	1	1	3	3	1.20	250
2	1	2	7	5	2.00	250
2	2	1	12	9	7.20	125
2	3	1	4	2	.80	250
2	4	1	12	9	3.00	300
2	5	1	6	5	1.67	300
2	6	1	16	13	4.33	300
TOTAL	–	–	60	46	2.03	1,775
Post-Treatment (One Year)						
2	1	1	0	0	0	150
2	1	2	1	1	.68	150
2	2	1	0	0	0	75
2	3	1	0	0	0	150
2	4	1	0	0	0	150
2	5	1	5	3	2.00	150
2	6	1	7	7	4.68	150
TOTAL	–	–	13	11	1.13	975
Pre-Treatment (Two Years)						
3	1	1	21	16	6.40	250
3	1	2	11	6	2.40	250
3	2	1	6	5	6.67	75
3	3	1	4	4	1.60	250
3	4	1	33	24	9.60	250
3	5	1	21	16	5.33	300
3	6	1	17	17	5.66	300
TOTAL	–	–	113	88	5.25	1,675
Post-Treatment (One Year)						
3	1	1	1	1	.68	150
3	1	2	0	0	0	150
3	2	1	0	0	0	0
3	3	1	1	1	.68	150
3	4	1	13	11	7.35	150
3	5	1	7	6	4.00	150
3	6	1	6	5	3.34	150
TOTAL	–	–	28	24	2.67	900

Conclusions

Although the trapping index dropped on Area 1 following treatment, it was believed to be of little significance since there was a drop on all three areas. The most pronounced drop occurred on Area 3. Rodent populations are generally eruptive or cyclic in Florida. It is believed that such population phenomena were responsible for the population drop on Area 1 rather than effects of the insecticide.

LARGE MAMMAL POPULATION SURVEY

Procedure

The method of conducting this survey consisted of counting tracks of the larger mammals at monthly intervals on dirt roads or fire lanes. Counting was done on roads where they traversed the interior of the area. This method was employed on Areas 1 and 2. These roads were graded frequently by the County Road Department thereby making tracking conditions satisfactory. Tracking was done on fire lanes on Area 3 since there were no interior roads on the area. Fire lanes were plowed frequently by the Florida Board of Forestry to facilitate tracking conditions. Four miles of roads or fire lanes were traversed on each area (2½ miles on Area 2) and the tracks of individual animals recorded. Tracking was done within one or two days following heavy rainfall whenever possible. Imprints were more distinct when made on wet soil. However, counts could not always be run under these conditions since there was only light rainfall during some months and the soil was either dusty or dry and firm. Under these conditions some of the smaller tracks, *i. e.,* rabbit and squirrel, were difficult to distinguish. Undoubtedly many of them were missed. However, since the same conditions were present on all the areas, there should have been no differentation in results.

This survey was conducted by Robert W. Murray. It began in August, 1959. Thirteen counts were made on each area prior to treatment and 13 following treatment.

Results

Results of the counts for each area before and after treatment are shown in Table III. The figures are based on tracks per mile of road or fire lane.

TABLE III

LARGE MAMMAL TRACK COUNTS

Area	*Rabbit*	*Raccoon*	*Squirrel*	*Skunk*	*Fox*	*Opossum*	*Bobcat*	*Deer*	*Mink*
Pre-Treatment									
1	2.00	1.60	.60	.30	.20	.20	.20	.00	.00
2	3.20	2.80	1.10	.70	.80	.30	.00	.20	.00
3	3.50	3.10	1.20	.50	2.80	.80	.00	.00	.01
Post-Treatment									
1	2.70	2.00	.40	.38	.30	.23	.20	.02	.00
2	3.60	2.70	.47	1.20	.90	.23	.00	.20	.00
3	3.30	2.80	.68	.40	2.10	.40	.00	.00	.02

Conclusion

The population of larger mammals tended to remain at approximately the same level throughout the study on all three areas. There was no apparent effect of the treatment on the populations on Area 1. Areas 1 and 2 showed slight increases in most species, while Area 3 showed a slight decrease. Strangely enough this area also showed the greatest drop in small mammal populations.

SONGBIRD SAMPLING STUDY

Procedure

The plan employed in this survey consisted of traversing established routes on each area by foot and recording the numbers and species of birds heard and seen. From four to six routes were established on each area at the beginning of the study. These routes were covered at two-week intervals between March 1959 and March 1962. Thirty-four trips were made to each area prior to treatment and 33 following treatment.

This survey was conducted by Dr. Henry M. Stevenson of the Zoology Department at Florida State University.

Results

Results of the survey are presented in Table IV.

TABLE IV

COMPARATIVE ABUNDANCE OF BIRDS ON STUDY AREAS

Area	*Total No. Species*	*Total No. Individuals*	*Av. Species Per Trip*	*Av. Individuals Per Trip*
Pre-Treatment				
1	110	7,498	35.20	220
2	120	11,083	38.40	325
3	115	17,243	40.70	510
Post-Treatment				
1	109	8,621	34.60	257
2	113	17,040	37.90	592
3	108	39,606	40.40	1,181
% Change				
1	−1.00	+ 15.00	−1.70	+ 16.00
2	−6.00	+ 54.00	−1.37	+ 55.00
3	−6.00	+129.00	−0.70	+132.00

Conclusion

From the data it appears that there was an increase in the number of individuals on all areas from the pre-treatment period through the post-treatment period. This is partially due to the fact that the pre-treatment period embraced two summers and one fall-winter, whereas, the post-treatment period embraced only one summer and two fall-winter periods. Obviously counts were higher during fall-winter periods when migrant flocks and winter residents were also present on the areas. The fact that the increases on Areas 2 and 3 are greater than on Area 1 is due to the large flights of red-winged blackbirds recorded migrating through these areas during the winter. These flights did not occur through Area 1.

Species population data of some of the most common permanent residents of the areas showed that some species decreased more on Area 1 than on Areas 2 and 3 following treatment. The house wren decreased 26 percent on Area 1 while it increased 59 percent and 53 percent respectively on Areas 2 and 3. The Bewick's wren decreased 100 percent on Area 1 while it registered 120 percent and 56 percent increases on Areas 2 and 3, respectively. The Maryland yellowthroat decreased 88 percent on Area 1 and showed 10 percent and 5 percent increases on the other areas. The loggerhead shrike decreased by 46 percent on Area 1 while it decreased by only 14 percent and 22 percent, respectively, on Areas 2 and 3.

These decreases are of not too much significance because of the small number of individuals of each species involved. There were also decreases in individuals of some species on the other two areas. Since these species are insectivorous, it is possible that the decrease in numbers was due to the effect of the insecticide upon the food supply, *i. e.,* the resulting food shortage, forcing them to leave the area. No evidence of bird mortality on the area was noted. Concerted efforts to find dead birds following treatment were unsuccessful. Certain investigators (Springer and Webster, 1951; Couch, 1946; and Rogers, 1948) have noted an exodus of birds from areas treated with DDT, apparently due to depletion of food supply.

The kill of insects on the area was essentially complete, especially among the terrestrial species. The Agricultural Experiment Station used certain species of arthropods and annelids as indicator forms (Rhoades, 1962). These were spiders, tiger beetles, spittle bugs, field crickets, earwigs, wireworms, and earthworms. Tiger beetles, spittle bugs, field crickets, and wireworms were reduced 100 percent from two to five months following treatment. Spiders and earwigs were reduced 90 percent five weeks following treatment. Earthworms were reduced 65 percent seven months following treatment. These species were back up within 70 or 75 percent of the pre-treatment population levels within a year after treatment. It is logical to assume that some of the insectiverous

species of birds were forced to find larder outside the area during the insect crash period.

SUMMER QUAIL AND DOVE CALL COUNTS

It was felt at the beginning of the study that information concerning the breeding quail and dove populations on the areas would be of considerable value. There was need for a sampling study that would indicate the population density of these birds on each area or population fluctuations that might occur between areas during the course of study. Investigators in various states have used the whistling cock count as an indicator of breeding quail populations. Rosene (1958) used this method of sampling quail populations on areas treated with insecticides and on untreated areas in Georgia. The dove cooing call count has been used as an indicator of breeding dove populations by various states for several years.

Procedure

The plan employed consisted of traveling roads within or surrounding the areas, stopping at one-half mile intervals, listening for five minutes, and recording the number of quail "bob-whiting" and the number of doves "cooing". Birds seen while parked or driving between stops were also recorded. The time of driving between stops was two minutes. Eleven stops were made per trip on each of Areas 1 and 3. Nine stops were made per trip on Area 2. Counts were conducted at 10-day intervals during the months of May, June, July and August two years prior to treatment and two years following treatment. Each count began at sunrise.

Data were recorded on prepared sheets that included temperature readings, sky conditions, wind direction and velocity, time of sunrise and time of each stop. Birds heard and seen on land adjacent to the areas were also recorded. It was thought this information might detect ingress or egress in the event movements should occur.

This study was conducted by Robert W. Murray.

Results

Results of the counts are presented in Table V. Counts are broken down to show the average per stop on each area for the two years prior to treatment and the two years following treatment.

TABLE V

COMPARATIVE QUAIL AND DOVE CALL COUNTS ON STUDY AREAS

	Average Per Stop			
Area 1	*Quail Heard*	*Quail Seen*	*Doves Heard*	*Doves Seen*
1959	.77	.07	.29	.02
1960	.79	.07	.14	.05
1961	1.30	.08	.33	.07
1962	.98	.33	.44	.08
Area 2				
1959	.99	.03	.22	.08
1960	1.60	.06	.25	.03
1961	1.67	.08	.40	.09
1962	1.22	.13	.37	.13
Area 3				
1959	.95	.06	.55	.27
1960	1.25	.04	.60	.30
1961	1.25	.10	.90	.30
1962	1.36	.08	.60	.49

Conclusion

It will be noted that there was an increase in the number of calls during the two post-treatment years over the two pre-treatment years on all the areas. The slight drop in the quail call count in 1962 on Areas 1 and 2 is due to the termination of calling at an earlier date in August than in former years. The increase in the breeding population of birds on Area 1 during the post-treatment period over the pre-treatment period indicates that the treatment had no effect on the breeding population.

WINTERING QUAIL POPULATION SURVEY

Procedure

The primary reason for conducting winter quail censuses on the areas was to learn what effect the treatment might have upon production on Area 1. One pre-treatment census during the winter of 1959-60, and two post-treatment censuses during the winters of 1960-61 and 1961-62 were conducted.

Method of censusing was by the covey whistle call count. This involved listening for individual coveys to whistle upon leaving the roost at daybreak and marking their locations on a map. It was necessary to be at a desired listening station 30 minutes before sunrise. At approximately 25 or 30 minutes before sunrise a few of the birds in each covey will whistle before leaving the roost. Whistling continues for a period of about one minute. During that period every covey within audible range can be mapped. Audible range on clear calm mornings is approximately three-eighth mile. The listening station for any morning would be located approximately three-fourth mile from the previous listening station. It is believed that this method was fairly accurate and that none of the coveys were counted more than once.

This study was conducted by Robert W. Murray.

Results

The number of coveys located by this method on each area is shown in Table VI.

TABLE VI

WINTER COVEYS ON EACH AREA

Winter	*Area 1*	*Area 2*	*Area 3*
1959-60	9	9	10
1960-61	10	11	12
1961-62	9	9	11

Conclusion

The number of wintering coveys on each area tended to remain essentially the same throughout the study. There was no evidence of the treatment affecting production on Area 1. Some of the coveys found with bird dogs on this area during the winters following treatment showed the coveys to be of normal size. Six birds were collected from different coveys during the first winter following treatment and sent to the U. S. Fish and Wildlife Service's Patuxent Wildlife Research Center at Laurel, Maryland, for chemical analysis. Although the birds were found to contain heptachlor epoxide at levels that had caused 40 percent decreased reproduction of birds in captivity, no evidence of decreased reproduction was noted on the area.

SUMMARY AND CONCLUSIONS

In the spring of 1959 the Florida Game and Fresh Water Fish Commission, the Florida Agricultural Experiment Station, and the Plant Industry Division entered a cooperative agreement to study the effects of the imported fire ant eradication program. The Experiment Station drew up a research project entitled "A Synecological Study of the Effects of the Fire Ant Eradication Program." Three study areas were selected, each approximately 1,280 acres in size. Two of these areas were infested with ants, the third was not. One of the infested areas was to be treated with heptachlor by the Plant Industry Division following a year of preliminary sampling studies of mammal and bird populations on the areas by the Game and Fresh Water Fish Commission and of arthropod sampling studies by the Experiment Station. The studies were to be continued for a period of two years following treatment. The study was designed to bring out any effect of the fire ants themselves on the population of animals as well as any population change induced by treatment against the ants.

The area scheduled for treatment was treated by airplane with 1.25 pounds per acre of technical heptachlor in granular form in September 1960. All cropland, pasture land, and open timber land was treated, which amounted to approximately 40 per cent of the area. The study continued for two years and was terminated in September 1962.

Sampling techniques were employed in studying bird and mammal populations that would indicate any population change that might occur on any of the three

areas. The studies consisted of: (1) a summer small mammal sampling study, (2) a large mammal sampling study, (3) a songbird sampling study, (4) a summer quail and dove breeding population sampling study, and (5) a wintering quail population sampling study.

None of the studies showed any significant effect of the treatment upon bird and mammal populations on the treated area. Also no effect of the ants themselves on bird and mammal populations was noted.

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EFFECTS OF KEPONE PEANUT BUTTER BAIT ON THE BOBWHITE QUAIL AND CERTAIN OTHER BIRDS *

By EDWARD P. HILL, III and MAURICE F. BAKER

Methods utilizing heptachlor and dieldrin in the early stages of the program to eradicate the imported fire ant (*Solenopsis saevissima richteri*) resulted in losses of wildlife sufficient to create concern among conservationists. [See George (1958) for a review of this subject.] Entomologists who were concerned with the problem conducted research to find safe and effective methods of controlling the fire ant. Beginning in 1957, Hays and Arant (1960) tested over 400 possible bait materials and 27 toxicants and found that kepone in peanut butter was effective as a fire ant bait. Work being done in 1960 by Smith (1961) indicated that bobwhite quail (*Colinus virginianus*) would not consume lethal amounts of this bait in the laboratory.

Kepone is a complex chlorinated polycyclic ketone ($C_{10}Cl_{10}0$). It is a stable white solid that is readily soluble in acetone and certain vegetable oils. As an insecticide it works mostly as a stomach poison. Its solubility in oil and its low toxicity as a contact poison were points in its favor as a prospective fire ant bait material.

Following many small-scale tests of kepone-peanut butter bait (Hays and Arant (1960), arrangements were made between the Plant Pest Control Division of the United States Department of Agriculture and Auburn University for a field test of this material wherein possible effects on wildlife would be an integral part of the test. High mortality to bobwhites during this test indicated the need for further laboratory work. It is the purpose of this paper to report the effects on birds during the field test and the results of subsequent laboratory tests.

FIELD TEST

Methods

The test area was located south of Camden, Wilcox County, Alabama. It was composed of a series of ancient river terraces and was mostly flat open land either in pasture or cultivation with small areas in woods. The best sum-

* A contribution of the Alabama Cooperative Wildlife Research Unit, Auburn University, the Alabama Department of Conservation, the U. S. Bureau of Sport Fisheries and Wildlife and the Wildlife Management Institute, cooperating.