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A MULTI-GENERATION TOXICITY EVALUATION OF P,P'-DDT AND DIELDRIN WITH JAPANESE QUAIL I. EFFECTS ON GROWTH AND REPRODUCTION

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ABSTRACT

A toxicity Evaluation of DDT and dieldrin was conducted using Japanese Quail. The effects of feeding DDT (5 and 50 ppm of diet) and dieldrin (0.1 and 1.0 ppm of diet) in this four generation study (parental, F_1, F_2 and F_3) were examined in terms of growth, viability, and/or reproduction of offspring. Ten groups (including controls and replicates of groups) contained 21 birds/group for the parental generation, and 21-35 chicks for each respective generation study. At 50 ppm DDT, a marginal decrease in egg hatchability of F_2 generation was evidenced; the decrease appeared related to a slight decrease in fertility rather than egg production or hatchability of fertile eggs. Data accumulated from all other experimental groups were within the expected range and were comparable to control data.

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INTRODUCTION

Marked declines in populations and reproductive success of several species of birds have been attributed to the widespread dissemination of residues of organochlorinated pesticides; changes in populations and reproductive success have been related to decreases in eggshell thickness[1-3]. Although these effects apparently are more pronounced in raptorial and fish eating birds, under proper laboratory conditions, decreases in eggshell thickness also have been demonstrated in galliform birds such as the Coturnix quail[3-5]. There appears, however, to be little, if any, definitive information regarding the reproductive success of galliform birds under controlled or environmental conditions when exposed to residues of organochlorinated pesticides. Acute and subacute, as well as short-term reproductive toxicity, studies involving organochlorinated pesticides[6-9] have been reported for Bobwhite quail and Ringneck pheasants. These and other studies, however, were based usually on short experimental periods and restricted to either chicks or breeding adults. Generally, multi-generation studies with avian species are limited by seasonal reproduction cycles when housed in outdoor runs or by relatively long periods to sexual maturity when housed in the laboratory. Because of rapid growth, early sexual maturity, and prolific egg production, Coturnix quail overcome many problems associated with other species; thus, these quail show promise as a laboratory animal for chronic toxicity evaluations of chemicals in avian species[10]. The present program was undertaken to determine and

correlate the effects of DDT and dieldrin on growth, feed consumption, egg production, reproduction, and mortality of Japanese quail through four generations.

METHOD

Japanese quail chicks (3-5 days old) were obtained from the breeding colony maintained at Stanford Research Institute and were randomly assigned into 10 groups of 21 birds/group. DDT (Nutritional Biochemicals Corp) of high purity was incorporated into the diet of replicate groups at levels of 5 ppm and 50 ppm. Dieldrin (Shell Chemical Company) of technical grade was added at levels of 0.1 ppm and 1.0 ppm. The remaining two groups controls were fed standard game bird diets. A premix of chemical and feed was prepared in a 20-qt dough mixer (Hobart) by combining preweighed quantities of DDT or dieldrin with finely ground game bird diet. The premixes were then mixed (Hobart) with powdered diet to give the final desired concentration of chemical. During the 10-week feeding period, growth, feed consumption, mortality, and egg production records were maintained. All eggs layed during weeks 9 and 10 were placed in commercial egg incubators. Total egg hatchability for each generation was calculated based on the number of chicks obtained vs total eggs set for hatch. Following the normal 18-day expected hatch period, an additional 48 hours were allowed and then unhatched eggs were broken open and examined visually to determine fertility and to calculate hatchability based on fertile eggs. Newly hatched chicks (20-35/group) were

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fed the same experimental diets as their respective parental generation for a 10-week period. In this manner, the study was undertaken with parental generation, continued through the F_1 and F_2 generations, and terminated when F_3-generation chicks reached 6 weeks of age. After each 10-week experimental-feeding period, surviving birds of each group were fed compound-free diets for a subsequent 12-week recovery period; body weight, feed consumption, egg production, and reproduction were measured during the recovery period. Birds were sacrificed periodically and samples of brain, liver, muscle, gonads and fat were retained for analysis of pesticide residues by gas chromatography; results of these analyses are reported separately.

RESULTS AND DISCUSSIONS

Average weekly body weights of Japanese quail fed diets containing DDT at 5 or 50 ppm and dieldrin at 0.1 or 1.0 ppm were similar to, or greater than, those of control birds throughout the parental (P), F_1, F_2, and F_3 generations. Results for the F_3 generation are summarized in Table I; data are presented as averages of replicate groups for each experimental treatment. Results obtained with the P, F_1 and F_2 generations were similar but are not presented since there was no statistical difference between the treated and control groups. Viability and survival of control and pesticide-fed birds were similar throughout the study; newly hatched chicks of each group in the F_1, F_2 and F_3 generations were placed on the same diet levels as their respective parents without producing mortality [illegible] 3% in excess of that of controls. Feed consumption, al-

TABLE 1

Average Weekly Body Weights (g) of F_3 Generation Japanese Quail Fed Diets Containing DDT or Dieldrin

Dietary Level (ppm)	Sex[b]	Weeks of Experiment[a] 0	1	2	3	4	5	6
				Control				
	M	9.1	29.1	60.5	71.7	88.1	97.4	100.4
	F			53.6	75.6	94.0	110.0	123.1
				DDT				
5.0	M	10.3	31.0	65.0	75.2	92.1	103.9	102.8
	F			66.9	76.8	94.1	112.7	122.6
50.0	M	8.5	29.0	61.3	73.5	92.2	101.1	104.3
	F			61.4	72.0	91.4	110.0	131.5
				Dieldrin				
0.1	M	11.2	29.7	61.3	71.8	88.0	99.1	98.4
	F			68.2	79.2	96.9	119.3	133.5
1.0	M	10.8	31.1	63.7	75.0	91.8	98.0	103.5
	F			69.5	80.0	97.8	114.1	128.4

[a]Each group consisted of 40 to 70 birds based on the average of replicate groups.
[b]Birds were wingbanded during second week and sexed during the third week.

though variable due to scattered instances of waste, showed no consistent decline or increase that could be attributed to the DDT or dieldrin.

Egg production, calculated as combined weekly averages, of the replicate groups of the P, F_1 and F_2 generations are summarized in Table 2; the experiment was terminated just prior to onset of egg production of the F_3 generation. The parental generation was 1 week

TABLE 2

Average Weekly Egg Production of Japanese Quail Fed Diets Containing DDT or Dieldrin

Dietary Level (ppm)	Chemical	Weeks of Experiment[a] 5 % Prod	6 % Prod	7 % Prod	8 % Prod	9 % Prod	10 % Prod
				Parental Generation			
0	---	5.4	35.3	76.7	86.7	77.3	80.7
5.0	DDT	2.0	35.2	60.4	81.3	80.2	87.7
50.0	DDT	1.8	38.8	62.2	79.6	72.3	87.2
0.1	Dieldrin	1.4	44.4	70.2	80.3	79.5	91.6
1.0	Dieldrin	8.7	39.3	79.5	86.6	81.3	76.8
				F_1 Generation			
0	---	0	14.5	65.2	70.1	58.9	88.7
5.0	DDT	0.4	14.1	59.6	75.4	75.7	87.0
50.0	DDT	0	9.8	62.0	69.0	79.2	73.2
0.1	Dieldrin	0	15.0	72.8	71.4	94.5	98.9
1.0	Dieldrin	0	12.7	42.9	41.7	71.5	74.1
				F_2 Generation			
0	---	1.5	42.0	70.6	80.6	81.0	81.3
5.0	DDT	0	35.3	73.9	88.0	89.0	86.1
50.0	DDT	2.1	37.5	63.3	75.7	79.5	80.7
0.1	Dieldrin	3.6	35.5	71.9	75.2	85.7	82.8
1.0	Dieldrin	7.2	28.6	61.6	74.5	77.9	80.1

[a]Calculations started at the onset of production; average of replicate groups.
[b]% production = (number eggs/number hen days) X 100.

old at the outset of the 5-week experiment; whereas, the F_1 and F_2 generations were started at birth. As summarized the Table 2, there were no consistent marked adverse effects of DDT or dieldrin on egg production of the P, F_1 or F_2 generations. At 1.0 ppm of dieldrin, onset of egg production of F_1 generation birds appeared to be somewhat delayed from that of the controls, but normal or near normal production levels were attained by the end of the compound-feeding period. Egg production was maintained at high and similar levels for each of these generations during the subsequent 12-week recovery period with each generation.

The reproductive performance of the P, F_1 and F_2 generations are summarized in Table 3. Egg hatchability based on total and fertile eggs set and egg fertility of the P and F_1 generation birds fed diets containing DDT at 50 ppm was within the range commonly found with these birds, but in the F_2 generation was somewhat lower than the controls, 57.9% compared to 70.0%. This apparent marginal decrease appeared to be reflective of lower egg fertility, 79% in this group compared to 95% fertility in the controls, rather than a decrease in hatchability of fertile eggs. This decrease may be due to chemical treatment or simply related to normal variations commonly observed in this species. Egg hatchability and fertility of the F_2 generation birds fed diets containing DDT at 5 ppm or dieldrin at 0.1 or 1.0 ppm were similar to that obtained in the control group.

Results of this multi-generation study with Japanese quail did not demonstrate marked adverse effects of p, p' DDT at levels up to

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TABLE 3

Egg Hatchability and Fertility of Japanese Quail Fed Diets Containing DDT or Dieldrin

Dietary Level (ppm)	Chemical	No. Eggs[a]	Hatchability[b] % Total	Hatchability[b] % Fertile	Fertility[c]
		Parental Generation			
0	---	154	65.5	67.8	96.8
5.0	DDT	122	67.2	67.2	100.0
50.0	DDT	132	70.5	72.7	97.0
0.1	Dieldrin	176	69.9	71.5	97.7
1.0	Dieldrin	159	65.4	67.1	97.5
		F_1 Generation			
0	---	252	75.4	80.9	93.3
5.0	DDT	264	75.8	79.4	95.5
50.0	DDT	265	64.5	71.3	90.6
0.1	Dieldrin	151	65.6	73.3	89.4
1.0	Dieldrin	264	71.2	73.7	96.6
		F_2 Generation			
0	---	230	70.0	73.5	95.2
5.0	DDT	233	68.7	73.4	93.6
50.0	DDT	233	57.9	73.4	79.0
0.1	Dieldrin	229	63.3	70.7	89.5
1.0	Dieldrin	234	66.2	70.5	94.0

[a]Eggs collected during 9th and 10th weeks; average of replicate groups.
[b]Number of chicks/total eggs or fertile eggs set X 100.
[c]Number of fertile eggs/total eggs X 100.

50 ppm or dieldrin at levels up to 1.0 ppm on reproduction, growth, or mortality under the conditions of this laboratory study. The responses of the Japanese quail to DDT generally extend and confirm results of subacute studies[11]. Japanese quail were reported[11] to be somewhat more sensitive than Bobwhite quail to diets containing

DDT with little, if any, difference in sensitivity to dieldrin. Assuming that reproduction responses of Bobwhite quail and Japanese quail may be similar to that obtained to acute studies, the dietary levels of both compounds used in the present study may have little, if any, significant adverse effect on reproduction of Bobwhite quail under laboratory conditions. Results, however, of this study should not be used to relate directly to any potential Bobwhite quail or pheasants under field conditions. Rigorously controlled field reproduction studies with these species should be undertaken in order to provide a more meaningful basis to compare and correlate field responses with effects found in laboratory studies.

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