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Effects of Dieldrin on Reproduction of Penned Hen Pheasants in the Second Generation

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EFFECTS OF DIELDRIN ON PENNED HEN PHEASANTS IN THE SECOND GENERATION

BY

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EFFECTS OF DIELDRIN ON PENNED HEN PHEASANTS
IN THE SECOND GENERATION

This thesis is approved as a creditable and independent investigation by a candidate for the degree, Master of Science, and is acceptable as meeting the thesis requirements for this degree, but without implying that the conclusions reached by the candidate are necessarily the conclusions of the major department.

Thesis Adviser Date

Head
Wildlife Management Department Date

EFFECTS OF DIELDRIN ON PENNED HEN PHEASANTS IN THE SECOND GENERATION

Abstract

WILLIAM LYMAN BAXTER

Effects of dieldrin on penned hen pheasants (Phasianus colchicus) which were the offspring of hens receiving encapsulated dieldrin the previous year were measured. Hens produced by the previous year's control group received 0, 6, 8, or 12 mg of dieldrin per week for 14 weeks. Hens from treated groups received 0 or 6 mg per week. Effects of dieldrin were evaluated by influences upon reproductive success. Mortality occurred in all groups receiving dieldrin, and appeared to be correlated with a reduction in egg production. Dieldrin lowered egg production by reducing food consumption in the 12 mg group and two groups which were offspring of 6 mg birds. Fertility and hatchability of eggs were significantly lower in groups where the hen had received dieldrin residues via the egg. Limited observations were also made on effects of dieldrin on behavior. Apparently 8 mg hens passed enough dieldrin in eggs to alter their progeny's behavior.

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INTRODUCTION

Modern agriculture in the United States is intensive and results in the covering of large areas with relatively pure cultures of food crops. This uniform concentration of plant life provides some insects with near optimum conditions for reproduction and dispersal, and often results in population irruptions. Use of toxic chemical compounds to control these insect populations is an integral part of agricultural production. Chlorinated hydrocarbons are highly toxic and residual chemicals in common usage. Previous research has shown that application of certain chlorinated hydrocarbons can be detrimental to wildlife populations. Rosene (1965:572) reported no live birds were seen or heard on an area 47 days after treatment with two pounds of heptachlor per acre. Scott, et al. (1959:423) reported almost complete annihilation of the breeding population of pheasants on an area treated with three pounds of dieldrin per acre.

Some studies indicate that sublethal quantities of chlorinated hydrocarbons may have an effect on reproduction. Hunt and Keith (1963:10) reported a 46.6 percent loss of pheasant chicks hatched from eggs collected in an area of high insecticide use, and a 27.0 percent loss of chicks from an area with little or no direct insecticide exposure. Genelly and Rudd (1956a:13) reported that 50 ppm dieldrin in the diet of pheasants produced high mortality in one month: twenty-five ppm resulted in heavy mortality in two months. Fertility and hatchability were not significantly affected in the

25 ppm group, but egg production and chick survival were lowered (Genelly and Rudd, 1956b:532). Atkins (1966) reported the only effect dieldrin had upon the reproductive success of penned hen pheasants in his study was a reduction in number of eggs laid in a group receiving 6 mg of dieldrin per week.

Behavioral changes associated with exposure to sublethal concentrations of chlorinated hydrocarbons have rarely been investigated, but some research indicates that changes of this nature may occur. For example, James and Davis (1965) found control groups of bobwhite quail (Colinus virginianus) committed significantly fewer errors in a discrimination program than groups that received as little as 20 mg/kg of DDT in their diets. McEwen and Brown (1966: 610) reported aberrant territorial breeding behavior among sharp-tailed grouse (Pedioecetes phasianellus) in a field study designed to determine the response of grouse to single oral doses of dieldrin and malathion.

The ring-necked pheasant (Phasianus colchicus) is the major upland game species in South Dakota. Because of the pheasant's recreational and economic importance, the people of South Dakota are interested in what effects insecticides may have on pheasant populations.

South Dakota State University started an extensive study on relationships of insecticides to pheasants in 1964. The first phase of the study was designed to determine effects of dieldrin on reproduction of penned hen pheasants. The present experiment was initiated in 1966 to determine effects of dieldrin on progeny of these birds. Objectives were to determine effects of dieldrin on: (1) consumption and utilization of food, weight, and egg production of hen pheasants; (2) fertility and hatchability of eggs; and (3) survival, weight gain and behavior of chicks.

METHODS AND MATERIALS

Adult hen pheasants were offspring of birds which received 0, 4, and 6 mg of dieldrin per week for 13 weeks in the spring of 1966. Hens produced by control birds (0 mg) were randomly divided into four groups and received 0, 6, 8, or 12 mg of dieldrin per week for 14 weeks. Hens produced by birds which received 4 mg of dieldrin were placed in two groups. One group received no dieldrin and the other received 6 mg per week. Hens produced by birds which received 6 mg of dieldrin in 1966 were treated in the same manner. These birds which received residues via the egg will be referred to as 4-0, 4-6, 6-0, or 6-6 mg groups throughout the paper. Cock pheasants used in the experiment were produced by the previous year's control birds. All birds were 9-12 months old and in their first breeding season when treated. At the start of treatment, sample size was eight hens in all groups except the 6 and 4-0 mg levels in which the sample size was seven.

Hens were held in individual cages (Fig. 1) that were a modification of those used by D. D. Suter of the South Dakota Pheasant Company, Canton, South Dakota. Hen cages were designed to facilitate handling of birds, identification of eggs, and measurement of food consumption. Dimensions of cages were 12 x 18 inches at the base and 12 inches high. Twelve cock birds were held in breeding cages 24 x 24 x 24 inches (Fig. 2).

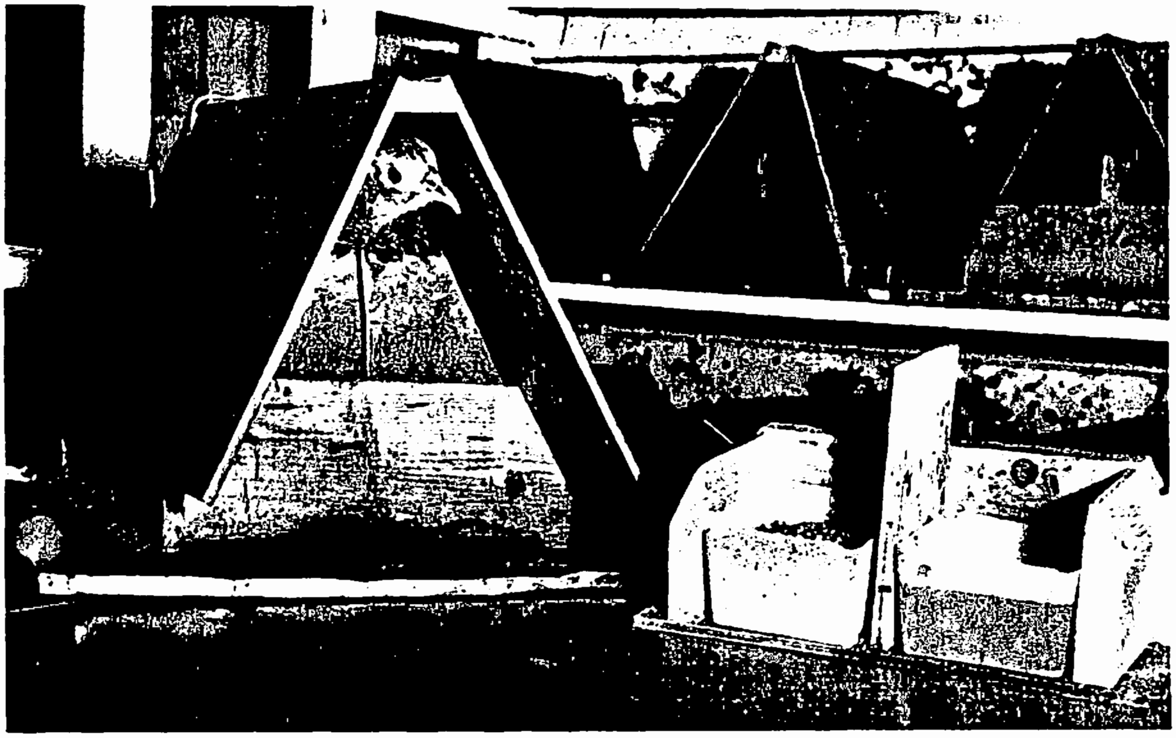

Fig. 1. Individual hen cages designed to permit measurement of food consumption and identification of eggs.

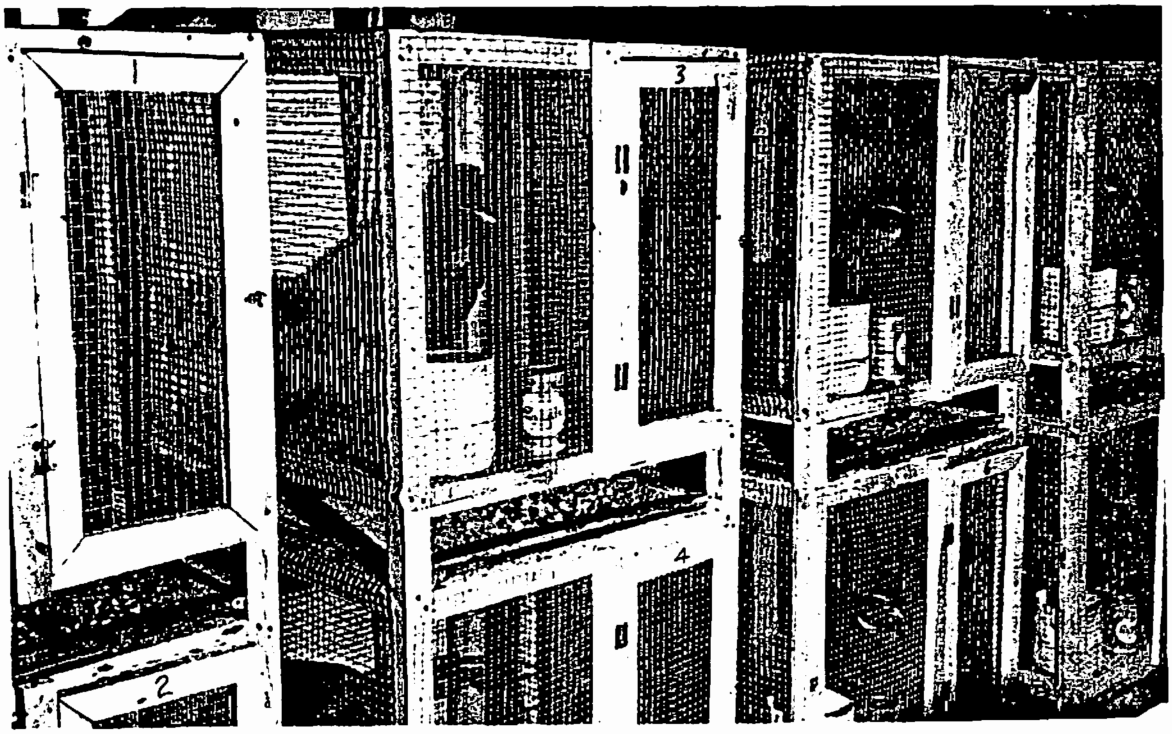

Fig. 2. Cages in which hens were bred at weekly intervals.

Pheasants were caged November 16 and induced to lay by photoperiod regulation. They were allowed 39 days on a 9 1/2 hour photoperiod to adjust to the different environment. Photoperiod was gradually increased to 16 hours and held constant for the remainder of the experiment. Dieldrin was first administered March 6 when the photoperiod was 14 1/2 hours, and 52 of the 62 hens had laid one or more eggs.

Technical grade dieldrin was ground, mixed with lactose, and given to the hens via glass tube in number 5 gelatin capsules. Control birds were given capsules containing lactose and no dieldrin. Capsules were used to insure that each hen in a group received the same quantity of dieldrin.

Hens were bred, and given a capsule at weekly intervals for 14 weeks. Food given each hen was measured daily, and average daily consumption was calculated. Eggs were collected, labeled, and set daily in a forced draft incubator. Operating temperature (99-100 F) and humidity (wet bulb 84-86 F) were kept constant. Eggs were moved to another incubator for hatching at the end of 20 days. Temperature (99-100 F) and humidity (wet bulb 88-90 F) were kept constant during hatching.

Chicks were banded and held in commercial battery brooders. Each chick was weighed weekly until 4-5 weeks old.

Feeds were formulated by Zip Feed Mills, Sioux Falls, South Dakota. Adult birds received pelleted pheasant breeder, and chicks were given pheasant grower.

Caloric values were determined with a Parr adiabatic oxygen bomb calorimeter. Feed, feces, and eggs were analyzed. Fecal samples were collected weekly for a 6 week period and saved for analysis. Duplicate runs were made on each oven-dried sample. The mean temperature was 70.9 F. The average temperature range was from 66-74 F.

Behavior was tested on a visual cliff which was a modification of one used by Tallarico and Farrell (1964:94). It consisted of a sheet of glass, 22 1/2 by 28 1/2 inches, 12 inches above the base of a box 22 1/2 by 28 1/2 by 27 inches. The base of the apparatus was completely lined with red and white 1/2 inch checked oilcloth. A second piece of oilcloth 14 1/2 by 22 1/2 inches was placed directly under one side of the glass. The glass field was divided by a runway 4 inches wide and 3 inches high. A holding box with sliding doors at both ends opened onto the runway.

Chicks hatched from eggs laid by hens receiving no dieldrin and 8 mg of dieldrin per week were tested in the first 30 hours of life. Chicks were placed in the holding box, and the door facing the runway was opened. They were allowed 10 minutes to make a choice of descending to the visually close or distant surface, after which their choice was recorded as shallow, deep, or no choice.

RESULTS

Mortality

Adult mortality (Table 1) occurred in all groups receiving dieldrin. No mortality occurred in the 0, 4-0, or 6-0 mg groups. Losses started two weeks after treatment and continued to occur throughout the study. Several hens were observed in the terminal stages of intoxification. They exhibited symptoms similar to those which characterize chlorinated hydrocarbon poisoning as described by Radeleff and Woodard (1955).

Food Consumption and Weight Change

Analysis of variance indicated a significant difference ($P<0.01$) between treatments for food consumption (Table 2). Dunnett's T test showed that the control (0 mg) group consumed significantly more food ($P<0.01$) than the 12, 4-6, 6-0, and 6-6 mg groups.

All groups lost weight during the study (Table 2). Analysis of variance indicated a significant difference ($P<0.01$) between treatments. Dunnett's T test showed that the controls (0 mg) lost significantly less weight ($P<0.01$) than the 8, 12, and 6-6 mg groups.

Even though the 6-0 mg group consumed significantly less food than the control (0 mg) group, weight change was not significant (Fig. 3). This is a reversal of the relationship between body weight and food consumption exhibited by the other treatments. Atkins and

Table 1. Number of second generation hen pheasants assigned to each group.

Treatment Level	Week of Treatment 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
0 mg	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
6 mg	7	7	7	7	7	7	7	7	7	5*	5	5	4	4	3
8 mg	8	8	8	7	7	7	7	7	5	5	5	4	3	3	3
12 mg	8	8	7	6	6	5	5	4	2	1	1	1	1	1	1
4-0 mg	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7
4-6 mg	8	8	8	8	8	8	7	6	5	5	4	4	4	4	4
6-0 mg	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
6-6 mg	8	8	8	7	7	7	6	6	6	5	5	4	4	4	2

* Weekly changes caused by mortality.

Table 2. Mean food consumption, change in hen weight, and egg production by groups. Values for egg production were transformed, transformation: $\sqrt{x+1/2}$. Statistical analysis was by least squares method.

Treatment Level	Food Consumption g/bird/week	Hen Wt. Change g/bird/week	Egg Production eggs/bird/week
0 mg	37.00	- 2.66	1.16
6 mg	37.19	-18.84	1.34*
8 mg	34.83	-24.36*	1.35*
12 mg	26.61*	-37.52*	.96*
4-0 mg	38.94	- 1.22	1.36*
4-6 mg	33.25*	-16.18	1.17
6-0 mg	31.10*	- 4.04	.76*
6-6 mg	24.36*	-27.48*	.76*

* Significantly different from control at 0.01 level.

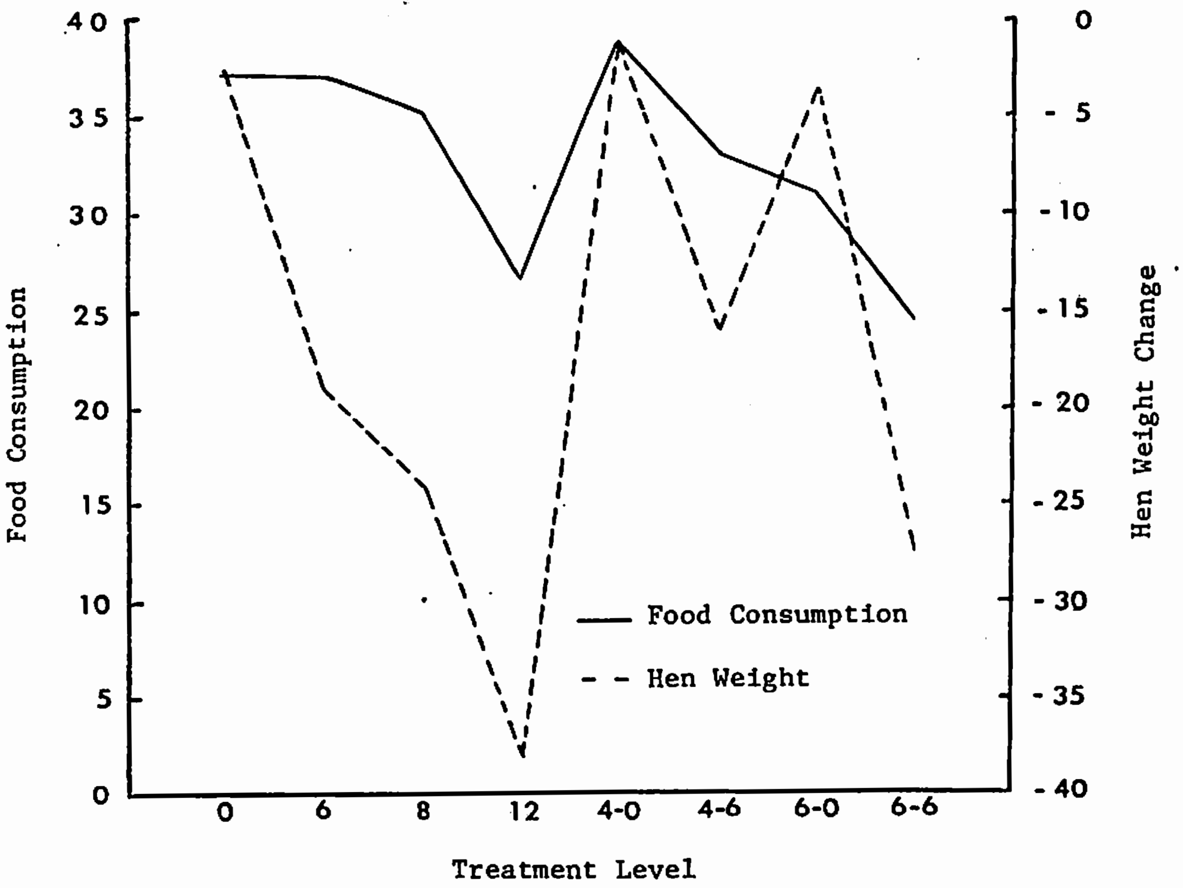

Figure 3. Mean food consumption and hen weight change in grams for second generation hen pheasants on different levels of dieldrin.

Linder (1967:749) noted a similar occurrence in hen pheasants receiving 2 mg of dieldrin per week. They suggested that dieldrin at the 2 mg level may have had a slight stimulatory effect on body weight. In the present study, the quantity of dieldrin 6 mg hens passed in their eggs possibly had a stimulatory effect on their progeny's body weight. No effect of this nature was noted in the 4-0 mg group.

Energy Utilization

Energy utilization was determined for three control (0 mg) and two 8 mg hens for the period April 20 to May 31 (Table 3). Metabolized energy was calculated by subtracting excretory energy (energy lost in feces) from gross energy (energy ingested). It was assumed that calories lost from urinary excretion were measured with the feces. Efficiency of food utilization (metabolized energy divided by gross energy times 100) was 76.5 percent for the controls and 74.7 percent for the 8 mg group. Maintenance energy was determined by subtracting the caloric value for egg production from metabolized energy. Analysis of variance detected no significant difference between treatments for energy utilization.

Egg Production

Egg production was lower than anticipated because of adult mortality and a disturbance in the building housing the experiment. Two weeks prior to the first treatment building plumbing was repaired.

Table 3. Mean energy utilization for control (0 mg) and 8 mg hen pheasants on a 16-hour photoperiod from April 20 to May 31.

Energy Utilization	Control (kcal)	8 mg (kcal)
Gross Energy	1,242.22	1,292.96
Excretory Energy	291.66	277.09
Metabolized Energy	950.56	1,015.09
Efficiency of Food Utilization %	76.51	74.73
Number of Eggs	55	64
Energy Value of Eggs	142.81	253.90
Maintenance Energy	807.75	761.97

The disturbance had a visible effect on bird behavior and depressed egg production in all groups.

Analysis of variance indicated a significant difference ($P<0.01$) between treatments for egg production (Table 2). Dunnett's T test showed that the controls laid significantly fewer eggs ($P<0.01$) than the 6, 8, and 4-0 mg groups, and significantly more eggs ($P<0.01$) than the 12, 6-0, and 6-6 mg groups.

Genelly and Rudd (1956b:533) proposed that insecticides affect egg production through a reduction in food consumption. Atkins and Linder (1967:749) reported that the rate of egg production was not consistent with the level of treatment but varied more closely with food consumption. Results of the present study appear to be similar to these findings with the exception of the control group (0 mg) which consumed slightly more food than the 6 and 8 mg groups but laid significantly fewer eggs (Fig. 4).

Fertility of Eggs

Fertility was based on visual examination of eggs after 28 days of incubation. Chi-square analysis of fertility detected a significant difference ($P<0.01$) between treatments (Table 4). An orthogonal set of comparisons and tests comparing each treatment level with the controls were conducted.

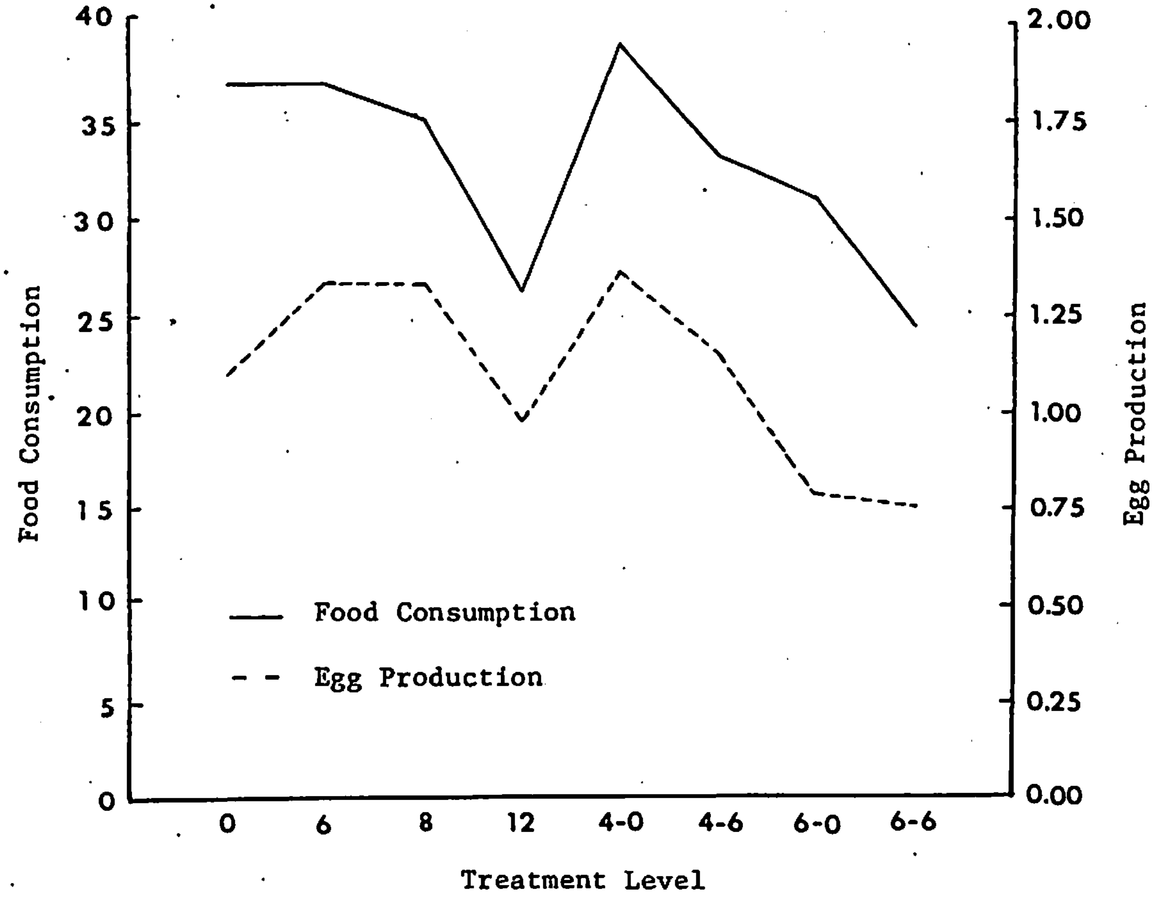

Figure 4. Mean food consumption in grams and mean egg production of second generation hen pheasants on different levels of dieldrin.

Table 4. Number of eggs incubated and percent fertility for each group. Percent fertility of eggs calculated from eggs incubated.

Treatment Level	Number of Eggs Incubated	Fertile Eggs	
		Number	Percent
0 mg	133	72	54.1
6 mg	155	42	29.6
8 mg	147	76	51.7
12 mg	25	16	64.0
4-0 mg	159	52	32.7
4-6 mg	114	24	21.1
6-0 mg	13	5	38.5
6-6 mg	10	1	10.0

Fertility of eggs laid by the controls was significantly higher ($P<0.01$) than fertility of eggs in the 6, 4-0, 4-6, and 6-6 mg groups. Fertility of eggs laid by hens in 6, 8, and 12 mg groups was significantly higher ($P<0.01$) than eggs produced by hens whose parents had received dieldrin in 1966. No significant difference was detected in the fertility of eggs laid by the offspring of birds which received 4 and 6 mg of dieldrin in 1966.

Hatchability of Eggs

Hatchability was analyzed by chi-square (Table 5). The 12, 6-0, and 6-6 mg groups were excluded from the analysis because of small sample size. Chi-square detected a significant difference ($P<0.05$) between treatments. Individual comparisons of each treatment level to the control and an orthogonal set of comparisons were computed. No significant difference was detected between the control and any treatment level. The orthogonal set indicated that a highly significant difference ($P<0.01$) existed between hatchability of eggs laid by 6 and 8 mg groups and those laid by 4-0 and 4-6 mg groups (Table 5).

Chick Survival and Weight Gain

Chick survival and weight gain were analyzed in all groups except the 12, 6-0, and 6-6 mg groups, eliminated because of small sample size (Tables 6 and 7).

Table 5. Hatchability of eggs from various treated groups.

Treatment Level	Number of Fertile Eggs	Chicks Hatched	
		Number Hatched	Percent of Fertile Eggs
0 mg	72	25	36.1
6 mg	42	19	45.2
8 mg	76	35	46.1
4-0 mg	52	10	19.2
4-6 mg	24	8	33.3

Table 6. Chicks hatched and percent survival of chicks. Statistical analysis by chi-square detected no significant difference between groups.

Treatment Level	Chicks Hatched	Percent Survival 2 Weeks	Percent Survival 4 Weeks
0 mg	25	80.0	80.0
6 mg	19	68.4	58.8
8 mg	35	65.7	62.9
4-0 mg	10	80.0	70.0
4-6 mg	8	50.0	50.0

Table 7. Mean weight gain of chicks (grams per bird per week). Figures in parentheses are numbers of birds weighed each week.

Treatment Level	Week 1	Week 2	Week 3	Week 4
0 mg	35.73 (22)	77.60 (20)	136.60 (20)	210.50 (20)
6 mg	34.87 (15)	78.38 (13)	135.75 (12)	202.18 (11)
8 mg	34.08 (24)	72.04 (23)	124.57 (23)	195.73 (22)
4-0 mg	30.88 (8)	63.50 (8)	124.00 (7)	198.28 (7)
4-6 mg	38.17 (5)	78.40 (4)	122.60 (4)	195.80 (4)

Genelly and Rudd (1956b:534) found that hatchability of eggs was not reduced from pheasants fed a diet containing dieldrin, but chick mortality was significantly greater in test groups the first two weeks. They concluded that the first two weeks after hatching were the most critical phase of pheasant reproduction with respect to insecticide contamination. Atkins and Linder (1967:751) reported that survival rates were not significantly different between 0, 2, 4, and 6 mg groups to two and eight weeks of age. However, they did note that survival was lower in 4 and 6 mg groups than in controls. In the present study most chick mortality occurred in the first two weeks, but chi-square analysis of chick survival detected no significant difference between treatments.

Chick weight gain was analyzed by the least-squares method. No significant difference was detected between treatments. Results appear to be consistent with the findings of Atkins and Linder (1967:752), who reported that weight gain was not consistently related to treatment level.

Chick Behavior

Walk and Gibson (1961:19) reported that day old domestic chicks possess excellent depth discrimination. Tallarico (1961:261), also working with domestic chicks, found a significant preference for the shallow side of a visual cliff within three hours after hatching. In the present study, control pheasant chicks performed similarly.

Chi-square analysis of chick performance on the visual cliff detected a significant difference ($P<0.01$) between chicks produced by control (0 mg) and 8 mg hens (Table 8). Thirteen of 15 control chicks chose the visually-close side. However, the majority of 8 mg chicks, 10 of 15, chose the visually-distant side. Dieldrin appeared to have changed the normal behavior pattern in pheasant chicks produced by hens receiving 8 mg per week.

Table 8. Visual cliff performance of pheasant chicks produced by hens receiving 0 and 8 mg of dieldrin per week. Statistical analysis by chi-square. Chicks recorded as no choice were excluded from analysis.

Decision	0 mg	8 mg
Shallow	13	5*
Deep	2	10
No Choice	2	4
Total	17	19

* Significantly different from the control (P<0.01).

DISCUSSION

Encapsulated dieldrin was evidently responsible for the death of female pheasants. This mortality appeared to be correlated with a reduction in egg production. Birds which received dieldrin and laid eggs throughout the study survived treatment while most of the non-laying hens died. One hen in the 12 mg group survived treatment, and she laid eggs the entire 14 weeks. All hens which received no dieldrin lived even though some did not lay eggs. Atkins (1966) reported no mortality in a test group of hens receiving 6 mg of dieldrin, and most of these hens laid eggs throughout his experiment. In the present study, several hens which were on the same treatment level, but not laying, died. Lowered egg production appeared to deprive hens of an efficient means of eliminating dieldrin from their systems. Lamb et al. (1967:27) reported that from 19 to 37 percent of the total dieldrin presented to hen pheasants in capsule form was deposited in the egg yolk.

Wild populations could be affected by application of chlorinated hydrocarbons prior to, or early in the nesting season. Application prior to egg production could result in adult mortality and a corresponding loss of reproductive potential in the population.

Reproductive success was also influenced by sublethal quantities of dieldrin. Dieldrin appeared to lower egg production by decreasing food consumption in the 12, 6-0, and 6-6 mg groups. It appeared that hens in the 6-0 mg group received enough dieldrin residues in eggs from which they hatched to lower food consumption, which in turn lowered egg production. Lamb et al. (1967:27) reported that dieldrin was deposited in eggs and that the amounts generally reflected the level of treatment. Atkins and Linder (1967:752) reported that the presence of up to 33.6 ppm of dieldrin in eggs did not affect hatchability. However, these levels of residues appeared to affect reproductive success of hens hatched from these eggs. Fertility and hatchability of eggs was significantly lower in groups where the hen had received dieldrin residues via the egg than in groups which received no dieldrin in this manner.

Under penned conditions dieldrin lowered reproductive success by: (1) increasing adult mortality, (2) decreasing food consumption which in turn lowered egg production, and (3) decreasing fertility and hatchability of eggs laid by hens which received dieldrin residues via the egg.

It appeared that the quantity of dieldrin 8 mg hens passed via the egg affected behavior in their progeny. Behavior is a system of internally directed activities designed to insure self and racial survival. It is directly related to the central nervous system. Since the chlorinated hydrocarbons affect the central nervous system, sublethal quantities of these chemicals could alter behavior and increase an animal's susceptibility to environmental stresses. For example, McEwen and Brown (1966:610) reported that animals exposed to sublethal insecticide intake may be more vulnerable to predation. They felt that this was a logical possibility since escape depends on alertness and flight capability.

This study was conducted under conditions which are not the same as those encountered by pheasants in the wild. Wild birds are not exposed to large doses of insecticides at regular intervals, but rather to a series of sharp increases and gradual decreases in the chemicals throughout the year. Under field conditions, pheasants may pick up insecticides in three ways: oral, dermal absorption, and inhalation. They are also subjected to several chemicals which in combination can be more toxic than one alone (Anonymous, 1966:19). In the present study, hens were only subjected to one insecticide with one mode of entry. They also were not subjected to environmental pressures wild birds must cope with, although they experienced other forms of stress. Each was in close confinement without an opportunity to exercise, and each was handled weekly for breeding, weighing, and capsule administration.

Further studies are necessary to increase our knowledge of the relationship of insecticides to pheasants and to relate this knowledge to pheasants in the wild. Cock birds should be treated under controlled conditions to determine the effects of insecticides on the male's role in reproduction. Wild birds and eggs should then be collected and analyzed to compare residue levels with those found in pen studies. Inferences could then be made concerning the relationships of dieldrin to pheasants in the wild.

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