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Effects of Dieldrin on Reproduction of Penned Hen Pheasants

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EFFECTS OF DIELDRIN ON REPRODUCTION OF PENNED HEN PHEASANTS

BY

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EFFECTS OF DIELDRIN ON REPRODUCTION OF PENNED HEN PHEASANTS

Abstract

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Pen studies to determine the effects of dieldrin on reproduction of the hen pheasant were conducted for two breeding seasons. Hen pheasants were caged individually and administered encapsulated dieldrin at weekly intervals. The first season, treatment levels were 0, 2 or 4 mg of dieldrin per hen per week. Hens receiving 4 mg weighed more and laid heavier eggs than the controls. However, these differences were not attributed to the effects of dieldrin, but to the condition of the hens when first treated. Hatchability of eggs from the 2 mg group was significantly higher for an undetermined reason. Feed consumption, egg production, fertility of eggs, and weight gain and survival of chicks were not affected by the treatments. The second season, treatment levels were 0, 2 4 or 6 mg of dieldrin per hen per week. It appeared that the 2 and 4 mg treatments did not influence feed consumption and hen weight sufficiently to affect the rate of egg production. However, the 6 mg treatment significantly reduced feed consumption, hen weight and egg production. Egg weights appeared erratic and not directly affected by dieldrin. Fertility and hatchability of eggs and survival and weight gain of chicks were not reduced by the treatments. Possibly the 2 mg treatment had a slight stimulatory effect on hen weight. The 6 mg treatment apparently affected reproduction by lowering the condition of the hens and reducing egg production.

EFFECTS OF DIELDRIN ON REPRODUCTION OF PENNED HEN PHEASANTS

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 Date
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INTRODUCTION

The use of toxic chemicals to control a variety of insect pests is integral to agricultural production and economics. One group of chemicals commonly used is the chlorinated hydrocarbons which are highly toxic and have long residual life. It is documented that field application of certain chlorinated hydrocarbons can be a hazard to wildlife. Robbins, Springer and Webster (1951) observed a 26% reduction in a breeding bird population on an area treated 5 successive years with DDT. Scott, Willis and Ellis (1959) reported almost complete annihilation of wildlife on an area treated with 3 pounds of dieldrin per acre. In each case, comparison with an untreated area or chemical analysis of specimens indicated that the loss was due to application of the insecticide.

In South Dakota, the Ring-necked Pheasant (*Phasianus colchicus*) is of economic importance. Thus, South Dakota State University is concerned with the effects insecticide use may have on the state's pheasant population. Since dieldrin has been commonly used to control insects in prime pheasant range, the present study was conducted to evaluate its effects on pheasant reproduction.

Some studies indicate that sub-lethal quantities of dieldrin may have an effect on reproductive success of pheasants. DeWitt (1956) reported reduced hatchability and survival of chicks when adult pheasants were fed a diet containing dieldrin.

In a similar study, Genelly and Rudd (1956) reported lowered egg production, hatchability and survival of pheasant chicks. In both experiments, adult pheasants were penned in groups and dieldrin was mixed with the feed.

The present study was initiated in 1964 and conducted for two years. Pheasants were caged individually and given encapsulated dieldrin. The objectives were to determine the effects of dieldrin on 1) rate of egg production, feed consumption and weight of hens, 2) weight, fertility and hatchability of eggs and 3) weight gain and survival of chicks.

I express sincere appreciation to my graduate advisor, Dr. Raymond Linder, for advice and direction given during the study and for assistance in preparation of this manuscript. Appreciation is extended to Dr. Donald Progulske for advice and helpful criticism in preparation of this paper. I sincerely thank Dr. Lee Tucker, experiment station statistician, for providing statistical analysis of the data. Thanks are also due to Dr. Alfred Fox for providing photos, Figures 1 and 2. I gratefully acknowledge the help and cooperation of my fellow graduate student, Mr. Donald Lamb, given throughout the study. I thank students, William Baxter, Curtis Bentz and Kenneth Marshall for assistance in collection of data. The funds for this study were provided through South Dakota Agricultural Experiment Station Project H-438.

MATERIALS AND METHODS

Adult pheasants were purchased from the South Dakota Pheasant Company, Canton, South Dakota, except the cocks used in 1966, which were offspring of the previous year's control (0 mg) group. All hens were 11-12 months old and in their first breeding season when first treated. Each year the hens were randomly divided into groups of 10 and put in individual cages (Fig. 1). In 1965, treatment levels were 0, 2 or 4 mg of technical grade dieldrin per hen per week and in 1966, treatment levels were 0, 2, 4 or 6 mg per hen per week. The chemical was ground and mixed with lactose powder in various proportions and given to the birds in size 5 gelatin capsules. Capsules containing only lactose powder were given to the controls.

The adult pheasants used in the experiment were held in individual cages. Cock cages, in which the hens were bred, were approximately 24 X 24 X 24 inches, (Fig. 2). Hen cages (Fig. 3), a modification of those used by D. D. Suter of the South Dakota Pheasant Company, were designed to achieve the following objectives: 1) measurement of individual feed consumption, 2) identification of each egg and 3) to facilitate handling of specific birds at specified times for weighing, administration of dieldrin and breeding purposes. They measured 12 X 18 inches at the base and 12 inches in height.

Fig. 1. Individual hen cages.

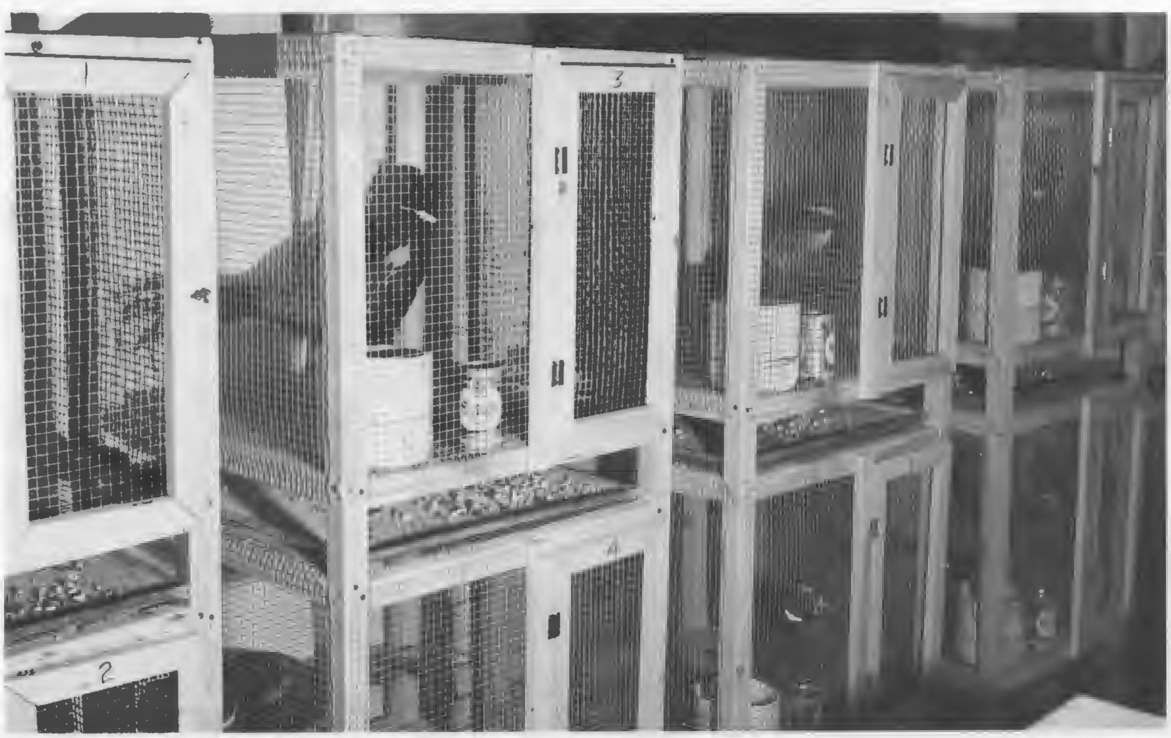

Fig. 2. Cock cages in which hens were bred.

Fig. 3. Hen cage with removable feed and water tray.

Fig. 4. Method of administering encapsulated dieldrin.

Pheasants were kept in darkened rooms and induced to lay eggs by regulation of the photoperiod. In 1965, the birds were put in cages March 2 and allowed 3 weeks on an 8 1/2 hour photoperiod to become adjusted to their new environment. During the next 5 weeks, the photoperiod was increased to 16 hours and kept constant for the duration of the breeding season. Dieldrin was first administered March 22, when the photoperiod was 9 3/4 hours and 9 of the 30 hens were laying. The second season, birds were put in cages December 16, and allowed 7 weeks on a 9 1/2-10 hour photoperiod to become adjusted. During the ensuing 6 weeks, as in 1965, the photoperiod was increased to 16 hours and held constant for the remainder of the breeding period. Dieldrin was first administered March 28, when the photoperiod was 16 hours and 38 of the 40 hens were laying.

Hens were bred, weighed and given a capsule (Fig. 4) at weekly intervals for 13 weeks. Each day eggs were collected, weighed and labeled and feed given each hen was measured. Every third egg laid by each hen was stored for chemical analysis and the remainder were set daily in a forced-draft incubator. Temperature (99-100'F) and humidity (wet bulb 86-90'F) were kept constant during incubation and hatching.

Chicks were banded at hatching and held in brooders. The brooder used in 1965 was improvised and equipped with one 250 watt infrared heat bulb. In 1966, commercial battery brooders were used. The chicks were pinioned at 1-2 weeks of age and moved to outdoor pens when 4-5 weeks old. Each chick was weighed weekly until 8-9 weeks old.

All birds were given feeds formulated by the Zip Feed Mills, Sioux Falls, South Dakota. Adult birds were given pheasant breeder feed in pellet form. Chicks were fed chick starter until 1-2 weeks of age and then given pheasant grower in crumble form.

An electronic computer was used to analyze all data not tested by chi-square. Only birds surviving the entire treatment periods were included in the analysis. In 1965, the number of birds surviving treatments was 8 in the 0 mg group, 9 in the 2 mg group and 4 in the 4 mg group. In 1966, all the birds, 10 per group, survived the treatments.

RESULTS

Feed Consumption and Hen Weight

Statistical analysis by the least squares method of the 1965 data detected no difference between treatments regarding feed consumption but a significant difference (0.05) between treatments for hen weight. Dunnett's T test showed the 4 mg group weighed significantly more (0.05) than the control (Table 1).

In 1966, analysis of variance indicated a highly significant difference (0.01) between treatments for feed consumption and hen weight. Dunnett's T test showed that the 4 and 6 mg groups consumed significantly less (0.05) feed than the controls and that the 2, 4 and 6 mg groups weighed significantly less (0.05) than the controls.

DeWitt (1955) observed that pheasants displayed a definite aversion to feed contaminated with dieldrin. In the present study, there was an inverse relationship between feed consumption and the level of treatment in all cases except the 4 mg group in 1965. Since the dieldrin was encapsulated, it had no effect on the palatability of the feed. Thus, the dieldrin reacted with the hens in an unknown manner to reduce feed consumption.

The difference detected in hen weights for 1965 may not represent sub-lethal effects of dieldrin. That year hens were

Table 1. Mean feed consumption, hen weight, egg production and weight of eggs by groups.

Level of Treatment	Feed Consumption gm/bird/day	Hen Weight gm/bird	Net Weight Change	Egg Production eggs/bird/week	Weight of Eggs gm/egg
1965					
0 mg	60.7	1030	+ 4.9%	3.9	32.4
2 mg	58.1	1040	+ 8.5%	3.4	32.4
4 mg	64.1	1101*	+16.1%	4.0	33.3*
1966					
0 mg	62.0	1315	- 3.5%	4.6	33.0
[illegible] mg	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
4 mg	59.1*	1270*	- 5.9%	4.3	33.3
6 mg	53.6*	1187*	-10.9%	3.4*	32.3*

* Significantly different from control at (0.05) level (Dunnett's T test).

allowed only 3 weeks to adjust to the cages which apparently was not enough time. When first treated, the birds were in an emaciated condition but rapidly gained weight the following two weeks (Fig. 5).

It appeared that the dieldrin killed the most emaciated birds in the 4 mg group. Three factors support this premise: 1) the acute oral LD50 is only 10 mg/kg (Rudd and Genelly 1956), 2) the emaciated condition of the hens and 3) in 1966, the hens were in excellent condition and all survived the same and higher levels of dieldrin. The analysis is based on only those hens surviving the entire treatment period. The number of such hens was 8 in the 0 mg group, 9 in the 2 mg group and only 4 in the 4 mg group. Thus, the high mean weight of the 4 mg group is probably not representative of a random sample of birds.

The differences declared significant by analysis of hen weights for 1966 may have existed throughout the period of treatment. Differences between group means were present during the first week of treatment and, except for the 6 mg group, remained relatively stable (Fig. 6). The net weight loss was 48 gm (3.5%) for the 0 mg group, 23 gm (1.8%) for the 2 mg group, 78 gm (5.9%) for the 4 mg group and 139 gm (10.9%) for the 6 mg group. The 4 mg group lost slightly more than the controls and only the 6 mg group exhibited a definite reduction in body weight as compared to the controls.

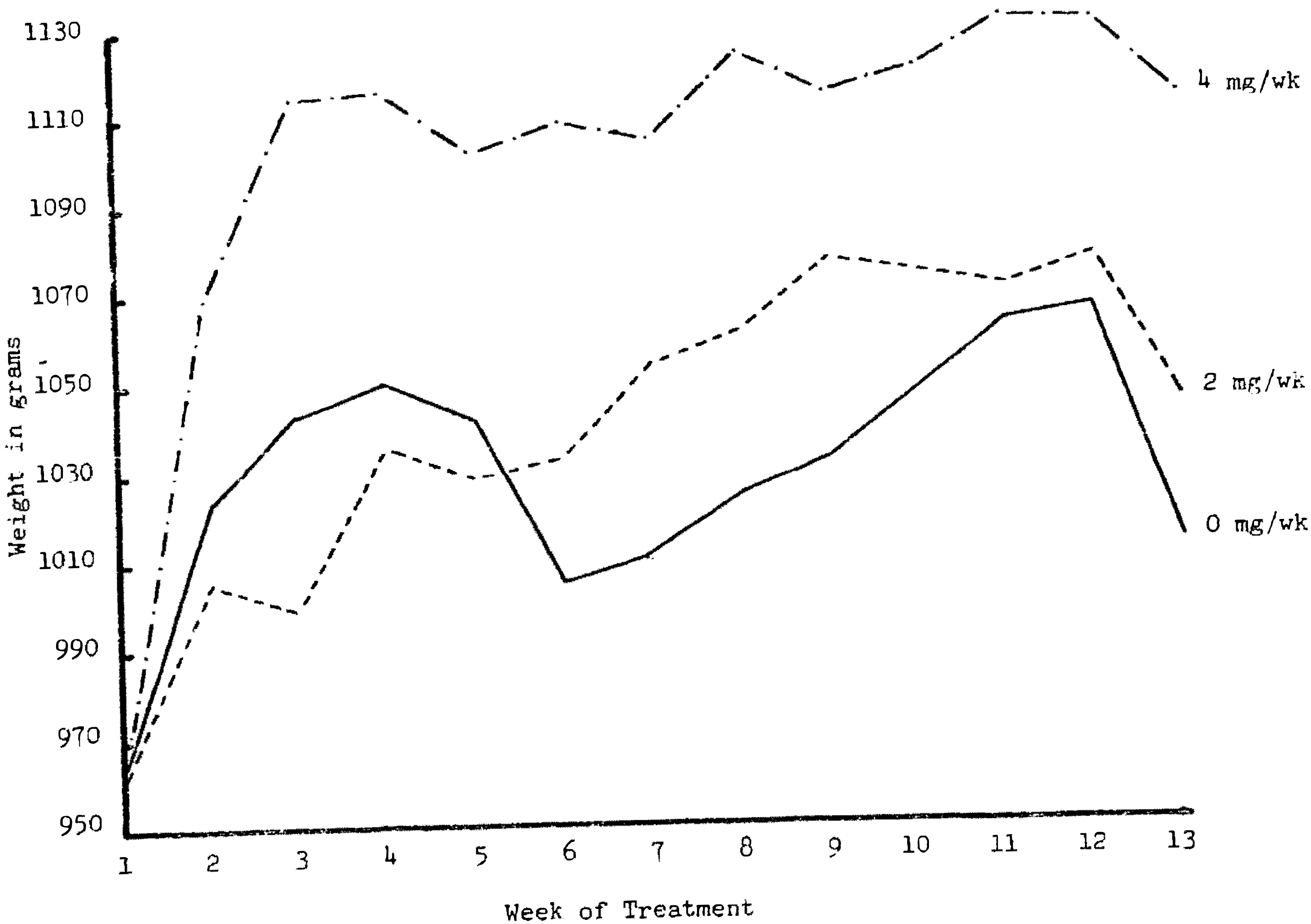

Fig. 5. Mean hen weight per group, 1965.

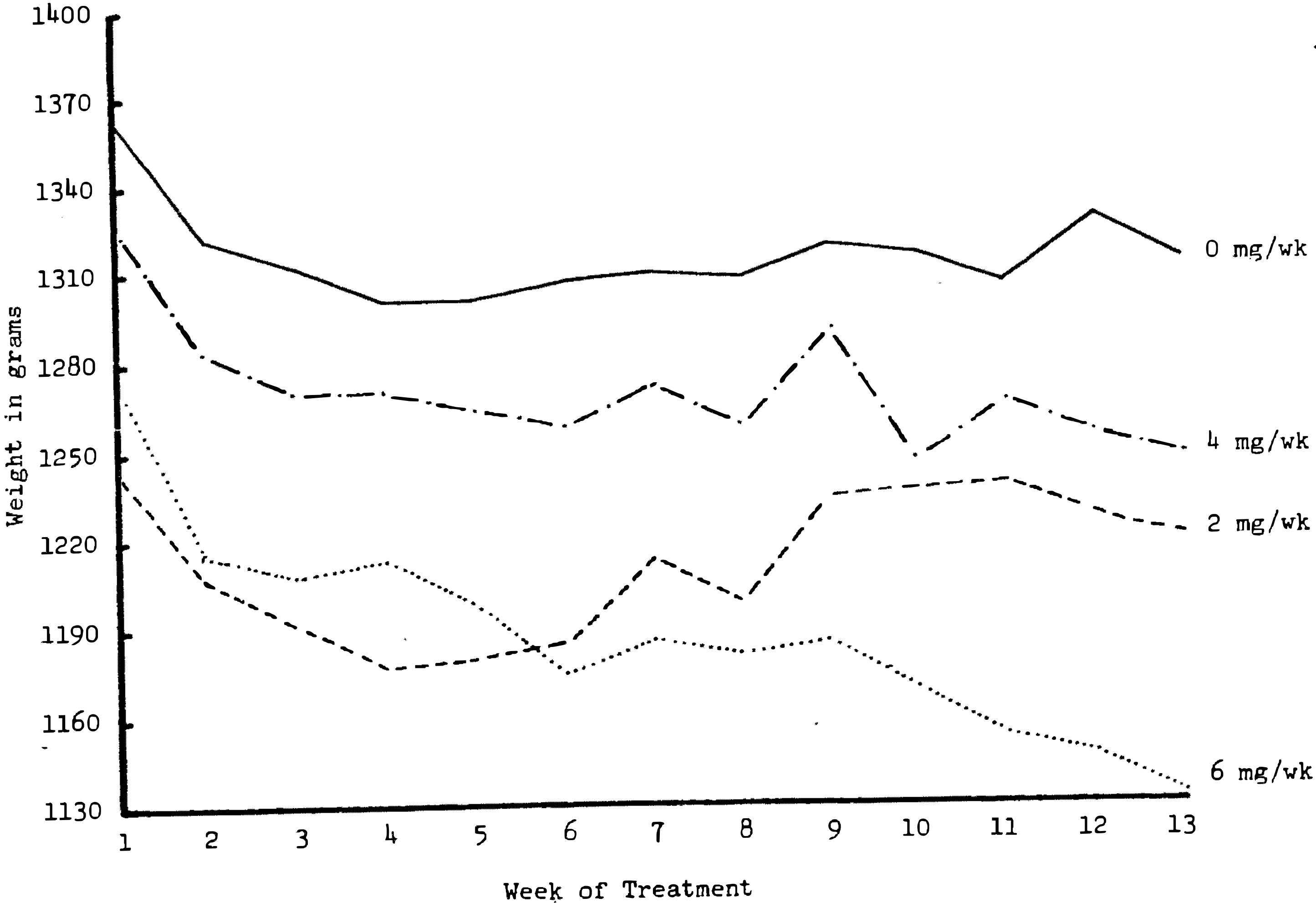

Fig. 6. Mean hen weight per group, 1966.

Hen weight exhibited a close relationship with feed consumption (Figs. 7-8), thus, dieldrin by influencing feed consumption could affect body weight and general condition of the birds. This would have far reaching effects in that the condition of the bird could affect various phases of reproduction such as egg production, fertility and hatchability of eggs and viability of chicks.

In 1965, the 2 mg group gained more weight than the controls and in 1966, the 2 mg group lost less weight than the controls. In each case, the 2 mg group consumed less feed than the controls. This is a reversal of the relationship between body weight and feed consumption for the other treated groups when compared with the controls. Possibly the 2 mg treatment of dieldrin had a slight stimulatory effect on body weight.

Egg Production

Hens of the 6 mg group laid significantly fewer (0.05) eggs than those of the controls (Table 1). Genelly and Rudd (1956) proposed that insecticides affect egg production through reduction of feed consumption. In the present study, rate of egg production was not consistent with the level of treatment but varied more closely with feed consumption. In 1965, feed consumption was not reduced by dieldrin and no effect on egg production was observed. In 1966, the mean feed consumption of the 6 mg group was 9.2 gm less than the controls and a corresponding reduction of egg production occurred. Mean feed consumption of the 4 mg group

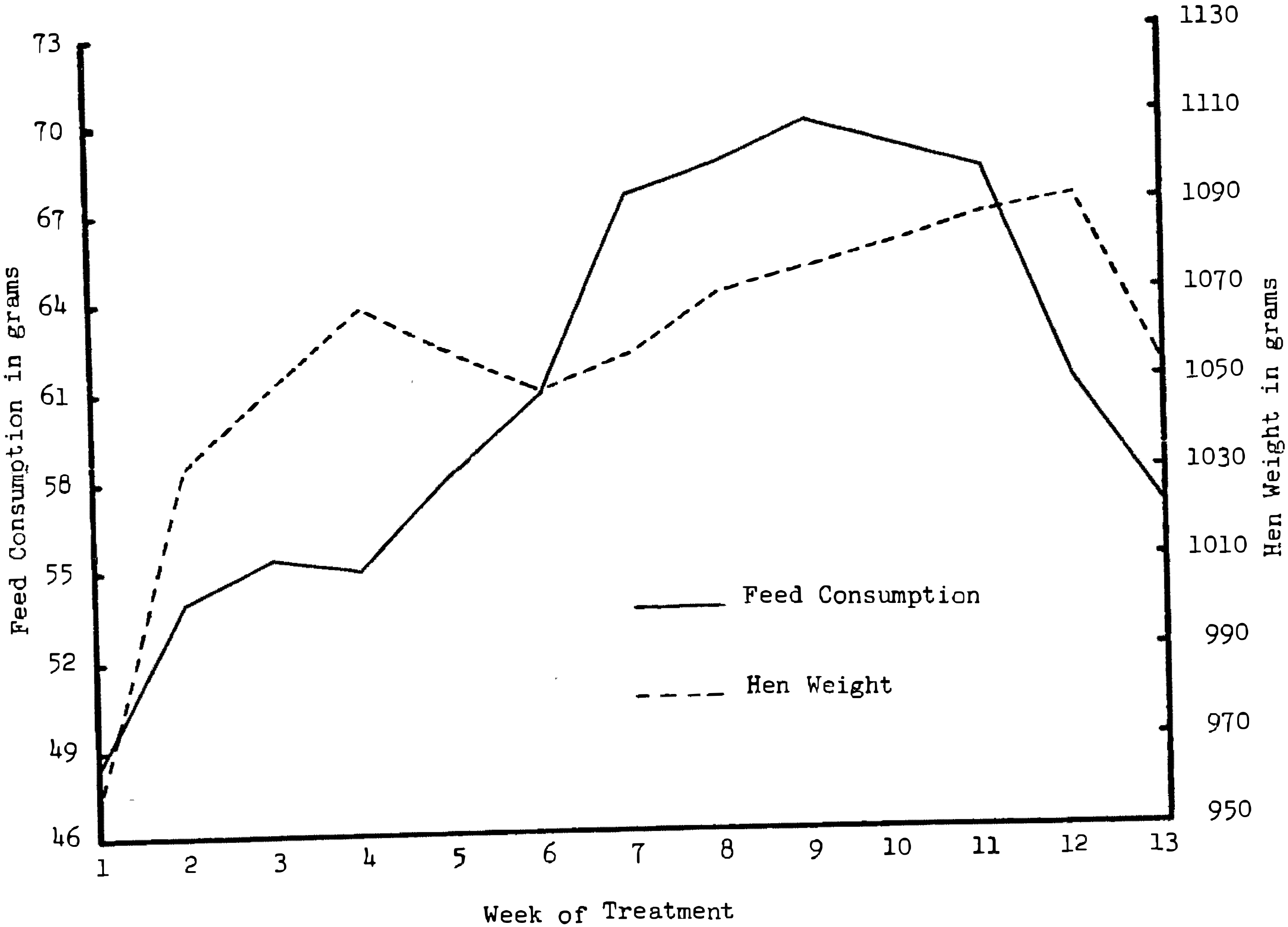

Fig. 7. Weekly mean feed consumption and hen weight, 1965.

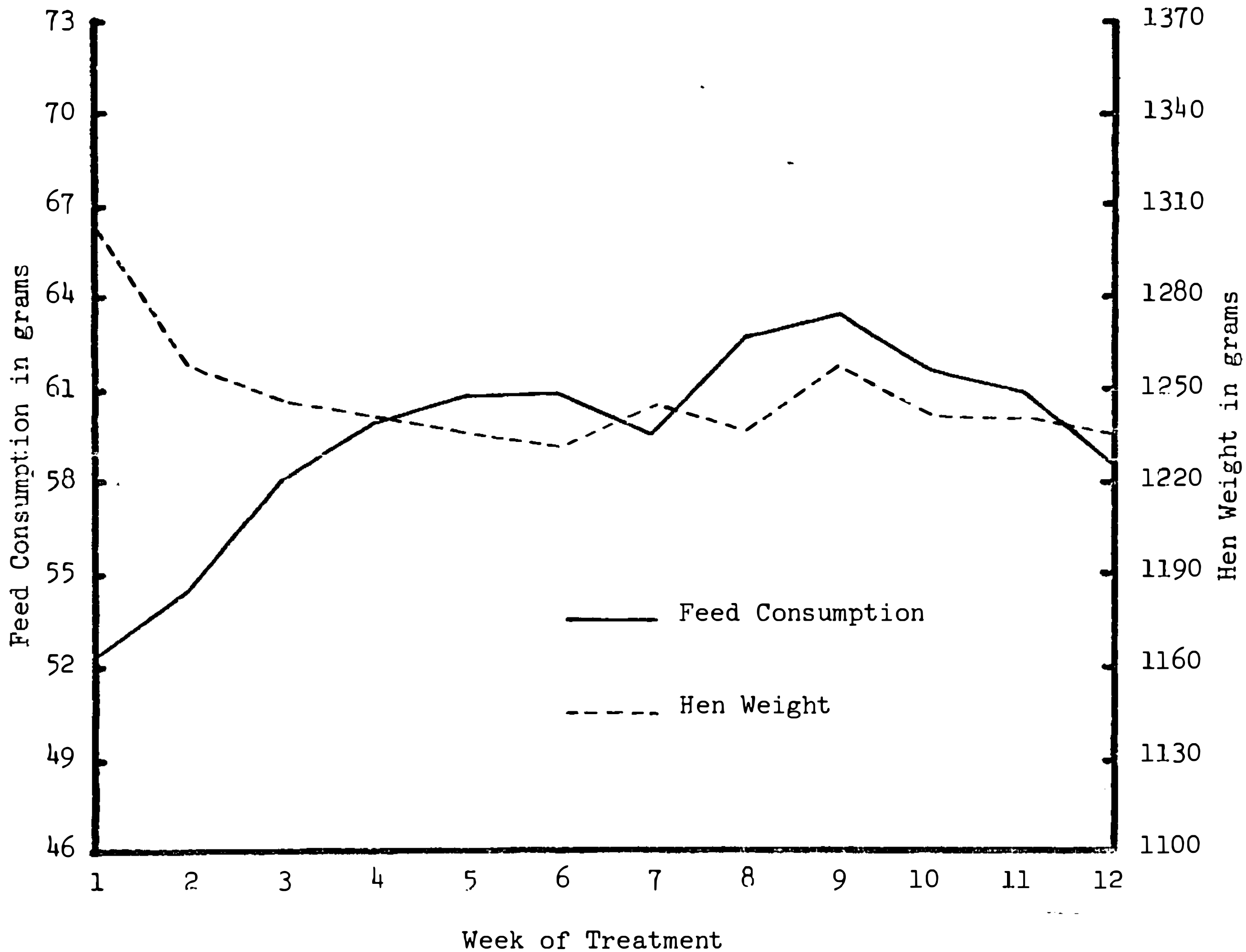

Fig. 8. Weekly mean feed consumption and hen weight, 1966.

was reduced 3.7 gm but egg production was not significantly reduced. It appears that only the 6 mg treatment had sufficient effect on feed consumption to reduce egg production.

Egg Weight

Analysis of egg weight by least squares detected a significant difference (0.05) between treatments for both years. Dunnett's T test of the 1965 data showed the 4 mg group laid significantly heavier (0.05) eggs than the controls. In 1966, the 2 mg group laid significantly heavier (0.05) eggs than the controls but the 6 mg group laid significantly lighter (0.05) eggs (Table 1).

Egg weight was somewhat erratic and did not appear to be directly influenced by any one factor. It appeared to vary with net weight change of hens which is an expression of feed consumption. In 1965, the 0 mg group hens gained 47 gm (4.9%), the 2 mg group gained 82 gm (8.5%) and the 4 mg group gained 154 gm (16.1%). In 1966, the net loss for each group was 48 gm (3.5%), 23 gm (1.8%), 79 gm (5.9%) and 139 gm (10.9%) respectively. Hens that gained the most or lost the least weight laid the heaviest eggs (Table 1). Possibly the egg weight of the 6 mg group was reduced by the dieldrin. However, Breitenbach, Nagra and Meyer (1963) observed that egg production of birds on limited intake diets was greatly decreased while egg size was only slightly reduced. The relationship of feed consumption, net weight change, body weight, egg production and level of treatment to egg weight is not clearly understood.

Chemical Analysis of Egg Yolks and Fat

It is well documented that dieldrin is deposited in the eggs and fat of birds receiving the insecticide in their diet (Rudd 1964). However, it was considered necessary to chemically analyze eggs and fat to determine if dieldrin was deposited in these tissues under the conditions of this study.

That portion of the 1965 study was completed and reported by Lamb (1966). He found that dieldrin was deposited in the yolk (Table 2) and that additional quantities of the insecticide were stored in the fat. Mean dieldrin content in fat of hens receiving the 2 mg treatment was 20.4 ppm, range 18.5 ppm - 23.9 ppm. The mean for the 4 mg group hens was 41.2 ppm, range 35.6 ppm - 42.6 ppm. Amounts found in the fat and yolk generally reflected the level of treatment. Eggs laid by the 0 mg group during the final week of treatment were analyzed and residues no greater than .1 ppm were found.

Additional analysis of eggs in the 1966 study was completed by Lamb (unpublished). Again, amounts found in the egg yolks reflected the level of treatment. Furthermore, the quantity of dieldrin deposited in the yolk by hens in the 4 mg groups was similar in both years.

Table 2. Dieldrin content of egg yolks (parts per million).

	1965[1] Treatment						1966[2] Treatment					
	2 mg/wk			4 mg/wk			4 mg/wk			6 mg/wk		
Week of Treatment	Hen 1	Hen 2	Hen 3	Hen 1	Hen 2	Hen 3	Hen 1	Hen 2	Hen 3	Hen 1	Hen 2	Hen 3
1	0.6	0.7	1.1	---	5.3	---						
2	2.6	---	2.3	---	9.3	---						
3	4.8	---	6.0	---	10.3	11.7						
4	5.0	5.2	6.0	---	12.4	13.0	11.6	11.6	7.5	21.4	13.3	27.3
5	5.7	6.1	6.8	---	11.9	15.4						
6	5.7	7.9	8.2	---	12.7	13.5						
7	6.3	9.0	9.8	40.1	15.8	17.3						
8	5.9	9.2	10.5	35.9	15.0	15.5	17.6	18.0	18.3	32.7	34.4	41.6
9	6.6	8.7	15.2	40.1	18.8	18.6						
10	6.5	8.2	13.2	35.6	18.9	19.1						
11	7.6	8.8	22.1	32.7	20.4	19.2						
12	7.8	7.6	26.5	27.5	18.0	---	20.6	20.0	---	---	52.4	45.5

1 Taken from Lamb, 1966.
2 Analysis completed by Lamb, (unpublished).

Fertility and Hatchability of Eggs

Chi-square analysis of fertility detected no significant differences between treatments either year. In 1965, hatchability of the 2 mg group was significantly higher (0.05) than the controls, however, the difference between the 4 mg group and controls was not significant. Differences in hatchability between treatment groups were not significant for 1966 (Table 3).

In 1966, fertility averaged 14.0 percent lower and hatchability 27.9 percent lower than in 1965. Since breeding and incubation procedures were the same both years, the differences between years cannot be explained.

The dieldrin apparently had no effect on fertility and hatchability except possibly hatchability of the 2 mg group in 1965. Azevedo, Hunt and Woods (1965) reported that eggs from hen pheasants fed diets containing 10 ppm DDT and 500 ppm DDT during egg laying had slightly higher hatchability than control eggs. At low levels, dieldrin may have a slight stimulatory effect on hatchability of eggs.

Survival of Chicks

Analysis of survival rates revealed no significant differences between groups for either the 0-2 week or the 0-8 week periods in both years (Table 3). Stanz (1952) reported that survival of pheasant chicks raised in confinement to 8 weeks of age was 92%.

Table 3. Percent fertility and hatchability of eggs and survival of chicks.

Level of Treatment	Fertility	Hatchability	Survival 0-2 weeks	Survival 0-8 weeks
1965				
0 mg	78.7	72.3	77.4	55.9
2 mg	70.4	85.0*	78.2	51.4
4 mg	77.4	73.6	71.7	44.4
1966				
0 mg	61.4	54.0	83.6	72.2
2 mg	63.8	51.5	89.1	71.0
4 mg	62.5	44.6	88.9	75.0
6 mg	59.5	46.3	79.4	74.1

* Significantly different from control at (0.05) level (chi-square).

In the present study survival was lower than anticipated because of overcrowding and disease. In 1965, overcrowding of chicks in the improvised brooder and the outdoor pens apparently increased mortality. In 1966, mortality during the 0-8 week period was increased by the apparent presence of an undetermined disease in the outdoor pens. It is unknown whether the stresses of overcrowding and disease influence the effects of dieldrin on the survival of chicks. However, the dieldrin did not significantly influence survival in the presence of these stresses.

Survival of chicks to 8 weeks of age, based upon the number of eggs incubated, was also analyzed by chi-square (Table 4). In both years no significant differences were detected between treatments.

Weight Gain of Chicks

Analysis of weight gains for 1965 by least squares revealed no significant differences between treatments (Table 5). All chicks, when 4-5 weeks of age, were moved to outdoor pens. During the first week while in the outdoor pens, all groups experienced a similar reduction in weight gain. The reduction probably reflected the reaction and adjustment of the chicks to their new environment.

In 1966, the 2 mg and 6 mg chicks, when 3-4 weeks of age, gained significantly more (0.05) weight than the controls. The

Table 4. Percent survival of chicks calculated from eggs incubated.

Treatment	Eggs Incubated	Chicks Live 8 Weeks
1965		
0 mg	202	28.2
2 mg	199	26.6
4 mg	93	17.2
1966		
0 mg	350	20.0
2 mg	365	20.8
4 mg	323	18.6
6 mg	247	16.2

Table 5. Mean weight gain of chicks (grams per bird per day).

	1965			1966			
Age	Treatment			Treatment			
in weeks	0 mg	2 mg	4 mg	0 mg	2 mg	4 mg	6 mg
1-2	1.9	2.0	2.2	3.4	3.6	3.6	3.6
2-3	4.0	3.8	3.9	6.4	6.7	6.6	6.8
3-4	6.5	6.8	7.6	9.0	10.1*	9.6	10.2*
4-5	8.1	8.3	8.5	12.7	12.6	12.5	12.7
5-6	5.8	6.6	5.7	1.7	2.4	1.1	1.5
6-7	9.3	10.1	11.9	9.3	9.8	9.9	9.4
7-8	9.9	9.7	9.5	12.6	12.1	13.4	13.4
8-9	10.2	10.6	10.1	13.1	13.3	12.1	13.5

* Significantly different from control (0.05) level (Dunnett's T test).

chicks were moved to outdoor pens at 4-5 weeks of age and suffered a greater reduction in weight gain than in 1965. This reduction was apparently caused by disease present in the outdoor pens which most of the chicks contracted at that time. The effects of the disease were so severe that weight gain of the chicks was affected for a two-week period (Table 5).

Except for the 5-6 and 6-7 week age classes, weight gain of chicks in 1966 averaged 2.8 gm per chick per week more than in 1965. It appears this difference reflected the less crowded conditions present in the brooders and outdoor pens in 1966.

In both years total weight gain was not consistently related to the level of treatment. In 1965, the total mean gain per chick per day was 6.5 gm for the 0 mg group, 6.6 gm for the 2 mg group and 6.7 gm for the 4 mg group. In 1966, the mean gains were 8.2 gm (0 mg group), 8.6 gm (2 mg group), 8.2 gm (4 mg group) and 8.6 gm (6 mg group) respectively. Differences that existed between groups were small and did not reflect the level of treatment. Furthermore, no pattern in weekly weight gain of any kind was established during the weighing period. The differences in gain between groups continually changed. Also, the rank of groups each week by weight gain was not consistent throughout, but constantly shifted. Apparently dieldrin was not the dominant factor influencing weight gain of chicks.

DISCUSSION

Reproduction is a major factor in determining the trend of pheasant populations. Thus, it is important that effects of dieldrin on reproduction be evaluated in terms of reproductive success which is dependent on inherent characteristics of the hen and many variable factors in the environment. In the present study, an attempt was made to hold all pheasants under identical conditions and make dieldrin the only variable between groups. Differences in reproduction could then be attributed to the treatments of dieldrin.

One factor of major importance in determining reproductive success is the general condition of the hen (Kabat et al. 1956). Feed consumption and body weight are closely associated with each other and indicators of conditon. In the present study, dieldrin apparently reduced feed consumption. This reduction brought about a corresponding decrease in body weight which was most pronounced in the 6 mg group. It appears that dieldrin, by reducing feed consumption, affected the condition of the hens, especially of those in the 6 mg group.

Westerskov (1955) stated that rate of egg production in pheasants is largely dependent on the condition of the hen. Condition of the hens in the 6 mg group apparently resulted in a statistically significant decrease in egg production. Evidently the condition of the hens in the other groups was not sufficiently affected to significantly reduce egg production. Since percent survival of chicks from eggs incubated was not significantly different between treatments, it appears that the only effect dieldrin had upon reproductive success was a reduction in number of eggs laid.

Chemical analysis of egg yolks showed dieldrin was deposited in the eggs and that these amounts generally reflected the level of treatment (Lamb 1966). Genelly and Rudd (1956) reported that dieldrin concentration in eggs from pheasants fed a diet containing the insecticide was highly variable. They found hatchability was not reduced but mortality of chicks was increased during the first two weeks after hatching. Hunt and Keith (1963) found dieldrin and DDT residues in pheasant eggs collected from the wild. They reported that chicks from eggs collected in an area of high insecticide use had considerably higher mortality rates than those from an area of no insecticide use. Dieldrin residues in these eggs ranged from 0-25 ppm and considerable residues of DDT were also present. In the present study, dieldrin residues in eggs laid in 1965 averaged 7.8 ppm for the 2 mg group and 19.4 ppm for the 4 mg group. In 1966, residues averaged 15.7 ppm for the 4 mg group and 33.6 ppm for the 6 mg group (Table 2). It appears that the presence of these amounts of dieldrin in the eggs did not affect hatchability of the eggs or survival and weight gain of the chicks.

In general, it appeared that dieldrin, at the 6 mg level, affected reproduction by reducing feed consumption and body weight, thus, lowering the condition of the hen and impairing the hen's ability to lay eggs. However, condition of the hens and dieldrin residues in the egg yolks apparently did not affect hatchability of eggs or viability of chicks. In view of these results, it appears dieldrin may affect reproduction in two ways. First, by decreasing rate of egg production, clutch size may be reduced. However, Hunt and Keith (1963) reported that clutch size in an area of high insecticide use was not significantly different from clutch size in an area of no insecticide use. Genelly and Rudd (1956) stated that under field conditions clutch size would not be reduced but that completion of the clutch would merely be delayed. Second, by lowering feed consumption and reducing body weight, the hen's ability to cope with the stresses of incubation, brooding, molting and the environment may be impaired. The extent to which the additional stress of dieldrin would affect survival and reproductive efforts of hens in the wild is unknown.

The conditions under which the hens were studied were not the same as those encountered by birds in the wild. Birds in the wild are potentially exposed to insecticides throughout the year. They are also exposed to a variety of insecticides which in combination may be more harmful (Anonymous 1966). In addition birds in the wild are required to incubate, brood and molt while withstanding the stresses of their environment. However, similarities did exist. First, the hens studied received dieldrin and deposited it in their fat and eggs. Second, the hens were subjected to the stress of caging. Kabat et al. (1956) reported that caging, under conditions somewhat similar to those in the present study, acted as a stress comparable in effect to reproduction. However, to what degree the stresses on the hens in the present study differed from those in the wild is not known.

Further studies are necessary to relate the findings of these studies to the wild. Eggs laid by wild hens should be collected and chemically analyzed to determine dieldrin content. These residues may then be compared with those found by Lamb (1966) in eggs from the pen studies. With certain limitations, inferences may be made regarding the effects of dieldrin on pheasant reproduction in the wild.

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APPENDICES

Appendix A. Weekly mean feed consumption (grams per bird).

	1965			1966			
	Treatment			Treatment			
Week No.	0 mg	2 mg	4 mg	0 mg	2 mg	4 mg	6 mg
1	46.7	47.1	51.6	55.4	53.2	53.8	47.1
2	51.4	48.0	63.0	58.7	55.4	54.6	49.3
3	54.8	52.5	59.0	60.8	60.2	55.8	55.7
4	55.0	52.2	57.8	61.7	63.5	58.3	56.6
5	57.1	54.8	62.4	63.6	65.3	62.3	52.0
6	59.7	61.2	61.3	60.0	65.6	62.8	54.8
7	67.2	66.0	69.1	64.7	61.3	58.7	53.1
8	71.5	64.5	69.3	63.9	65.6	62.7	58.0
9	74.3	65.2	70.2	68.4	67.6	59.2	58.5
10	72.7	63.8	70.7	62.8	63.7	64.1	55.9
11	68.4	65.4	70.7	67.1	63.4	60.8	52.7
12	61.1	56.4	65.2	65.9	63.4	55.9	49.6
13	49.2	58.0	63.1	----	----	----	----
Mean	60.7	58.1	64.1	62.8	62.4	59.1	53.6

Appendix B. Weekly mean hen weight (grams).

	1965			1966			
	Treatment			Treatment			
Week No.	0 mg	2 mg	4 mg	0 mg	2 mg	4 mg	6 mg
1	966	962	959	1361	1244	1326	1271
2	1022	1006	1070	1321	1209	1285	1217
3	1043	999	1115	1312	1192	1270	1208
4	1050	1036	1117	1300	1180	1270	1213
5	1042	1029	1102	1300	1181	1264	1198
6	1005	1033	1109	1307	1185	1260	1175
7	1011	1054	1104	1310	1214	1273	1187
8	1025	1061	1125	1309	1200	1259	1180
9	1032	1077	1115	1320	1234	1291	1185
10	1048	1074	1120	1316	1236	1245	1169
11	1063	1071	1131	1307	1237	1266	1153
12	1066	1078	1131	1319	1227	1256	1146
13	1013	1044	1113	1313	1221	1248	1132
Mean	1030	1040	1101	1315	1212	1270	1187

Appendix C. Mean number of eggs laid (per bird).

	1965			1966			
	Treatment			Treatment			
Week No.	0 mg	2 mg	4 mg	0 mg	2 mg	4 mg	6 mg
1	2.3	1.4	1.5	5.2	5.3	5.6	4.6
2	2.4	1.8	2.5	5.3	5.3	5.5	4.3
3	3.1	1.7	3.3	5.1	5.0	5.1	4.3
4	3.8	2.7	3.3	4.6	5.3	4.5	4.8
5	4.6	3.4	3.5	4.4	5.4	4.9	3.5
6	4.1	3.2	3.8	4.6	4.8	4.6	2.9
7	4.4	4.2	4.3	4.6	4.9	4.2	2.5
8	4.5	4.3	5.0	4.9	4.2	3.6	3.4
9	5.0	4.4	5.3	3.9	4.6	4.3	3.3
10	4.8	4.0	4.5	4.1	4.1	4.1	3.1
11	4.6	5.2	4.8	4.1	4.1	3.3	1.7
12	3.9	4.4	5.3	4.0	4.3	1.6	1.8
13	3.4	3.6	4.8	---	---	---	---
Mean	3.9	3.4	4.0	4.6	4.8	4.3	3.4

Appendix D. Mean weight of eggs (grams).

	1965			1966			
	Treatment			Treatment			
Week No.	0 mg	2 mg	4 mg	0 mg	2 mg	4 mg	6 mg
1	32.0	32.0	32.8	33.1	33.5	33.9	32.2
2	33.3	31.7	34.6	33.1	33.9	33.6	31.9
3	33.7	31.3	34.5	33.1	34.0	33.7	32.5
4	33.0	33.0	33.6	33.3	34.1	33.6	32.3
5	32.7	33.6	34.7	33.1	34.2	33.2	32.2
6	32.1	33.5	34.2	32.8	33.9	33.8	32.2
7	32.0	32.3	33.5	33.5	34.4	33.3	32.6
8	32.3	32.1	33.1	33.5	34.2	33.3	32.9
9	31.8	32.2	33.3	33.3	34.4	32.7	32.9
10	32.9	32.4	33.6	33.3	34.6	33.1	33.0
11	31.7	32.3	32.4	32.9	34.1	32.3	32.7
12	32.5	33.0	31.8	33.0	33.7	32.0	33.3
13	31.4	31.0	32.4	----	----	----	----
Mean	32.4	32.4	33.3	33.2	34.1	33.3	32.3