Effects of Dieldrin and PCB's Upon the Production and Morphology of Japanese Quail Eggs

by

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Considerable interest in the effects of certain environmental contaminants upon the avian egg has developed in recent years. Egg production was lowered in Japanese quail (Coturnix coturnix japonica) fed 700 ppm or more p,p'-DDT for 20 days (GISH and CHURA, 1970), but not in Japanese quail fed p,p'-DDT at levels up to 400 ppm for 60 days (SMITH et al., 1969). WALKER et al. (1969) observed reduced egg production in Japanese quail after several weeks of exposure to 20, 30, and 40 ppm dieldrin, but 10 ppm dieldrin did not affect egg production over 18 weeks of exposure. DDT at 200 ppm and dieldrin at 20 ppm did not affect egg production in chickens (DAVISON and SELL, 1972). Reductions in pheasant (Phasianus colchicus) egg production upon dieldrin administration have been reported (ATKINS and LINDER, 1967; BAXTER et al., 1969; GENELLY and RUDD, 1956).

Pheasant egg production was lowered with PCB 1254 treatments of 12.5 and 50 mg/wk (DAHLGREN and LINDER, 1971). Chicken egg production was reduced with treatments of 10 ppm Aroclor 1242 or 100 ppm Aroclor 1254 (KEPLINGER et al., 1972), 20 ppm Aroclors 1232, 1242, and 1248 (CECIL et al., 1972), and 10 or 20 ppm Aroclor 1248 (SCOTT, 1971).

Eggshell thinning has been observed in various species of birds fed DDE, DDT, dieldrin, or a mixture of dieldrin and DDT (HEATH et al., 1969; LEHNER and EGBERT, 1969; LONGCORE et al., 1971; MC LANE and HALL, 1972; PEAKALL, 1970; PORTER and WIEMEYER, 1969; WIEMEYER and PORTER, 1970). Japanese quail fed 2.5, 10, and 25 ppm p,p'-DDT for 26 weeks all had significantly thinner eggshells than controls (STICKEL and RHODES, 1970). The ration in the above study contained 3.5% calcium carbonate and 1.5% dicalcium phosphate. Japanese quail fed 100 ppm o,p'-DDT and p,p'-DDT for 45 days on a low calcium (0.56%) diet produced eggs with thinner shells and lower calcium content than normal

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(BITMAN *et al.*, 1969). However, Japanese quail fed 100 ppm p,p'-DDT or p,p'-DDE with an adequate (2.7%) calcium diet for 74 days did not produce eggs with thinner shells (CECIL *et al.*, 1971).

Chickens fed 10 ppm Aroclor 1242 or 100 ppm Aroclor 1254 had thinner eggshells than controls (KEPLINGER *et al.*, 1972). Increased numbers of membranous and broken eggs occurred when Japanese quail were fed 100 ppm Aroclor 1242 for 60 days, but not with quail fed 100 ppm Aroclor 1254 (BITMAN *et al.*, 1972).

The objectives of this study were to study the effects of dietary dieldrin and PCB's upon egg production, the photoperiod-induced cessation and resumption of egg-laying, and egg morphology in Japanese quail.

MATERIALS AND METHODS

Seven-week-old Japanese quail were randomly placed on *ad libitum* control diets, and diets of dieldrin and Aroclors 1242, 1254, and 1260 at two levels. The dieldrin (99+% pure, recrystallized HEOD) was supplied by Shell Oil Company, and the Aroclors were supplied by Monsanto Chemical Company. Dietary levels were 3.1 and 50 ppm dieldrin, 312.5 and 5000 ppm Aroclor 1242, 78.1 and 1250 ppm Aroclor 1254, and 62.5 and 1000 ppm Aroclor 1260. The dieldrin and Aroclors were dissolved in soybean salad oil and mixed thoroughly in Purina Game Bird Layena ration. This ration contains 2.3-3.3% calcium. The control ration consisted of salad oil and the same layer ration. Treatments lasted for 21 days, followed by a 1-day fast. The photoperiod regime consisted of 7 days with 10 hours of light daily, followed by 15 days with 24 hours of light.

Egg production was determined by dividing the total number of eggs produced during the treatment period by the number of days each hen spent in the treatment period (hen-days), thus accounting for any deaths of hens during treatment.

Eggs were marked according to treatment group and date of collection. They were weighed on Ainsworth and Mettler balances, and measured at their maximum lengths and girths with a Glogau vernier caliper. Eggshell fragments were removed from the inner shell membrane at the equators of the eggs. Shell thicknesses were measured to the thousandth of a mm with a Gaertner measuring microscope fitted with a micrometer eyepiece.

Egg production data were analyzed by the Chi-Square method, and egg morphology data were analyzed by the Least-Squares Analysis of Variance in conjunction with Dunnett's test (Steel and Torrie, 1960).

RESULTS AND DISCUSSION

Egg production by hens at all treatments and levels was significantly lower than production by control birds (Table 1). The higher levels of dieldrin and PCB's 1242, 1254, and 1260 all resulted in considerably lower production values than the corresponding lower levels.

Egg-laying patterns as influenced by photoperiod were altered considerably by the higher level dieldrin and PCB treatments. The control hens produced eggs throughout the experiment. The 50 ppm dieldrin hens ceased egg-laying after the 4th day on the 10-hour photoperiod, and did not resume egg production until the 8th day under the 24-hour photoperiod. The 5000 ppm PCB 1242 hens ceased egg-laying after the 3rd day and did not resume egg production until the 9th day. The 1250 ppm PCB 1254 hens ceased egg-laying after the 5th day, and did not resume egg production on the 24-hour photoperiod. The 1000 ppm PCB 1260 hens produced an egg on the 7th day preceded by a 3-day interval with no eggs, and did not resume egg production until the 11th day on the 24-hour photoperiod.

The corresponding lower level treatments had little effect upon the cessation of egg production, but delayed resumption in the PCB treatment groups was observed. Resumption of egg-laying occurred on days 2, 9, 6, and 7 under the 24-hour photoperiod for the 3.12 ppm dieldrin, 312.5 ppm PCB 1242, 78.1 ppm PCB 1254, and 62.5 ppm PCB 1260 treatment groups, respectively.

JEFFERIES (1967) observed delayed ovulation onsets in Bengalese finches (*Lonchura striata*) fed p,p'-DDT for 6 weeks at levels ranging from approximately 11 to 54 ppm. Ring doves (*Streptopelia risoria*) fed 10 ppm p,p'-DDT for up to 6 weeks had delayed ovulation (PEAKALL, 1970). Japanese quail fed 100 ppm p,p'-DDT or p,p'-DDE over a 74-day period showed an egg production lag of 3 weeks (CECIL *et al*., 1971).

Egg weights were significantly reduced ($p<.01$) at the lower level of dieldrin, and at both levels of PCB 1260 (Table 2). Weight data were not collected for the higher levels of dieldrin and PCB 1242. Egg weight reductions were not observed in chickens fed 20 ppm dieldrin or 200 ppm DDT (DAVISON and SELL, 1972), or in chickens fed 20 ppm of various Aroclors (CECIL *et al*., 1972).

TABLE 1

Egg Production for Control Birds and Birds Administered Dieldrin, PCB 1242, PCB 1254, and PCB 1260.

Treatment	Level	Number of Hen-days[1]	Number of Eggs Produced	Eggs per Hen-day
Control	----	139	76	0.55
Dieldrin	3.1 ppm	264	125	0.47**
Dieldrin	50 ppm	132	28	0.21***
PCB 1242	312.5 ppm	132	60	0.45*
PCB 1242	5000 ppm	51	12	0.24***
PCB 1254	78.1 ppm	242	71	0.29***
PCB 1254	1250 ppm	33	6	0.18***
PCB 1260	62.5 ppm	264	127	0.48*
PCB 1260	1000 ppm	69	8	0.12***

[1]Number of hens x days each hen spent in the treatment period.
*Significant difference at the $p < .050$ level.
**Significant difference at the $p < .025$ level.
***Significant difference at the $p < .005$ level.

In both of these experiments, the chickens were in continuous egg production. The photoperiod regime employed in this study may have played an important role in producing the observed results. As the birds ceased egg production, greater body burdens of dieldrin and PCB's could have accumulated than if they were in continuous egg production. Considerable quantities of insecticides and PCB's have been reported to be excreted via the egg yolk (SMITH *et al.*, 1969; WALKER *et al.*, 1969; LAMB *et al.*, 1967; DAHLGREN *et al.*, 1971).

Eggs were significantly shorter ($p < .01$) and narrower ($p < .01$) than controls on the 5000 ppm Aroclor 1242 and 62.5 ppm Aroclor

TABLE 2

Egg Weight, Length, Width, and Shell Thickness for Control Birds and Birds Administered Dieldrin, PCB 1242, PCB 1254, and PCB 1260 (Figures are means, standard errors, and numbers of observations).

Treatment	Level	Mean Weight (grams)	Mean Length (millimeters)	Mean Width (millimeters)	Mean Shell Thickness (millimeters)
Control	----	9.95 ± 0.15 (n=54)	30.7 ± 0.2 (n=71)	24.5 ± 0.1 (n=71)	0.174 ± 0.002 (n=73)
Dieldrin	3.1 ppm	8.92 ± 0.30 (n=13)	31.0 ± 0.3 (n=31)	24.4 ± 0.2 (n=31)	0.160 ± 0.002** (n=36)
Dieldrin	50 ppm	-----------	30.4 ± 0.3 (n=24)	24.7 ± 0.2 (n=24)	0.161 ± 0.004** (n=29)
PCB 1242	312.5 ppm	10.31 ± 0.14 (n=55)	31.2 ± 0.2 (n=58)	25.3 ± 0.1 (n=58)	0.166 ± 0.002* (n=60)
PCB 1242	5000 ppm	-----------	28.7 ± 0.5** (n=12)	23.0 ± 0.3** (n=12)	0.156 ± 0.006** (n=12)
PCB 1254	78.1 ppm	9.57 ± 0.17 (n=43)	30.0 ± 0.2 (n=68)	24.6 ± 0.1 (n=68)	0.153 ± 0.002** (n=71)
PCB 1254	1250 ppm	8.86 ± 0.45 (n=6)	29.1 ± 0.6 (n=6)	24.1 ± 0.4 (n=6)	0.142 ± 0.007** (n=6)
PCB 1260	62.5 ppm	8.80 ± 0.13** (n=69)	29.4 ± 0.2** (n=72)	23.9 ± 0.1** (n=72)	0.156 ± 0.002** (n=75)
PCB 1260	1000 ppm	8.06 ± 0.61** (n=4)	29.4 ± 0.7 (n=5)	23.8 ± 0.4 (n=5)	0.132 ± 0.006** (n=8)
Total Eggs--10-hour photoperiod		8.83 ± 0.14 (n=108)	29.7 ± 0.2 (n=147)	24.1 ± 0.1 (n=147)	0.153 ± 0.002 (n=152)
Total Eggs--24-hour photoperiod		9.59 ± 0.21** (n=136)	30.2 ± 0.2* (n=200)	24.5 ± 0.1** (n=200)	0.158 ± 0.002 (n=218)

*Significant difference at the $p < .05$ level.

**Significant difference at the $p < .01$ level.

1260 treatments (Table 2). Eggs produced under the 24-hour photoperiod were heavier ($p<.01$), longer ($p<.05$), and wider ($p<.01$) than those produced under the 10-hour photoperiod. This might be explained on the basis of the birds being older and having increased feeding time under the 24-hour photoperiod.

Significant eggshell thinning occurred with all dieldrin and Aroclor treatments (Table 2). Eggshell thickness means were similar at both levels of dieldrin. Penned mallards fed 1.6 and 10 ppm dieldrin showed a similar trend, where the higher treatment resulted in little further thickness reduction (LEHNER and EGBERT, 1969). Shell thinning may be evident over a short feeding period, as DDT-dosed Japanese quail showed shell thickness declines by the second and third days (STICKEL and RHODES, 1970). Shell thinning was not observed in pheasants administered 4 mg/wk dieldrin (DAHLGREN and LINDER, 1970), or in chickens fed 200 ppm p,p'-DDT or 20 ppm dieldrin (DAVISON and SELL, 1972).

The shell thinning results of this experiment agree with the findings of KEPLINGER (1972) in chickens fed 10 ppm Aroclor 1242 and 100 ppm Aroclor 1254. BITMAN *et al.* (1972) found shell thinning in Japanese quail fed 100 ppm Aroclor 1242, but not in quail fed 100 ppm Aroclor 1254. No shell thinning was observed by others upon administration of Aroclors to different species (CECIL *et al.*, 1972; DAHLGREN and LINDER, 1971; HEATH *et al.*, 1970; PEAKALL, 1971).

Possible explanations for differences observed in egg production, egg weight, or eggshell thickness of this experiment as compared to others include differential species sensitivities, and employment of different photoperiodic regimes, treatment levels, and treatment periods.

The general trends of decreased egg production, increased egg laying resumption times, decreased egg weights, and decreased shell thicknesses at the higher level PCB treatments were associated with severe weight loss and high mortality (CALL, 1972). However, at the lower level PCB treatments and at both treatments of dieldrin, weight changes were similar to controls and mortality due to treatment did not occur.

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