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EFFECTS OF POLYCHLORINATED BIPHENYLS ON PHEASANT REPRODUCTION, BEHAVIOR, AND SURVIVAL[1]

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Abstract: Cock pheasants (*Phasianus colchicus*) were given single capsules weekly containing either 0 or 25 mg polychlorinated biphenyls (PCB) for 17 weeks in the spring of 1970. Hen pheasants mated to these cock groups were given single capsules weekly containing 0, 12.5, or 50 mg PCB (Aroclor 1254). Among groups receiving PCB, egg production was depressed significantly ($P < 0.05$), and the number of eggs that were pipped but not hatched was increased significantly ($P < 0.05$). Even though weekly weight changes of hens, fertility and hatchability of eggs, mortality of adults, and eggshell thickness did not appear to be affected by PCB, total reproductive success was depressed. Behavior, on a visual cliff, of chicks hatched from hens given 50 mg weekly was significantly different ($P < 0.01$); more of them jumped to the visually deep side or made no choice of sides than chicks from other groups. Mortality of chicks from hatching to 6 weeks of age was significantly greater ($P < 0.01$) in the offspring of hens receiving 50 mg PCB weekly, and surviving chicks of this group were significantly lighter ($P < 0.05$) in weight than other groups at 6 weeks of age.

Polychlorinated biphenyls have been detected in wildlife in Europe (The New Scientist 1966, Holden and Marsden 1967, Holmes et al. 1967, Jensen et al. 1969, Koeman et al. 1969) and in the United States (Risebrough et al. 1968, Anderson et al. 1969, Bagley et al. 1970, Risebrough 1970). This chlorinated hydrocarbon was found as a residue in tissues of both seabirds and land-dwelling species.

The induction of steroid enzymes in the liver by PCB has been demonstrated in both laboratory rats (Street et al. 1969) and in pigeons (Risebrough et al. 1968); and since the capacity of PCB to induce these enzymes is as potent as or more potent than DDT, PCB's have been implicated in eggshell thinning. Sax (1963:596) indicated that the liver of man could be injured by PCB; liver damage has been shown for guinea pigs, laboratory rats, and domestic rabbits by Miller (1944). McCune et al. (1962) and Flick et al. (1965) found that PCB fed to young chickens produced edema and pathological changes in internal organs. The objective of our study was to evaluate the effects of PCB on reproduction, survival, and behavior of pheasants.

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METHODS

We used Aroclor 1254 supplied by the Monsanto Co., St. Louis, Missouri. Hens were purchased in the winter of 1970 from the South Dakota Pheasant Co., Canton, and cocks were raised by us from birds previously obtained from the Canton source. Two groups of five cocks each were given weekly either a 00-size gelatin capsule containing corn oil, or one containing corn oil in 9:1 dilution with 25 mg PCB. Each cock group was mated with three groups of five hens, in which each hen was given weekly a single corn oil placebo capsule, 12.5 mg PCB, or 50 mg PCB. Hens and cocks were maintained in separate cages. Cocks were dosed for 17 weeks from February 13 to June 5, and hens from February 20 to June 12.

General care, diet, and maintenance were the same as those described for a dieldrin experiment by Baxter et al. (1969), except that hens in the present study were given a tablespoonful of oyster shells in their food cups once each week.

Eggs were gathered from March 7 to June 19 and set weekly in a forced-draft incubator. Within 36 hours of hatching, chicks were taken from the incubator, placed directly on a visual cliff (Tallarico and Farrell 1964), and given 5 minutes to jump to the visually deep or shallow side. Chicks from this study and those hatched from a concurrent dieldrin reproduction study were placed together in brooders until they were 6 weeks of age; each bird was then weighed to the nearest gram.

Adults were also weighed weekly to the nearest gram. Eggshells of hatched eggs from all 15 weekly egg groups were measured, without the membrane, to the nearest 0.01 mm, using a micrometer at three points around the midline perpendicular to the long axis, as described by Dahlgren and Linder (1970). Unhatched eggs from weekly egg groups 8–15 were broken, dried for 24 hours, and the eggshells, including the membrane, measured.

Fertility of unhatched eggs was based on a visual inspection for evidence of embryonic development.

RESULTS AND DISCUSSION

Effects of PCB on Condition and Reproduction

Only 2 hens died from among the 30 hens and 10 cocks under study; both hens had received 50 mg PCB weekly. Analysis of weekly changes of weight of cocks and hens tested by analysis of variance showed no effect ($P > 0.05$) from the administration of PCB. Flick et al. (1965), who fed 200 and 400 ppm, and McCune et al. (1962), who fed at a dietary level of 100–800 ppm, found that the growth of chicks of the domestic chicken was retarded by Aroclor 1242.

The averages of eggs laid per hen per day (Table 1) among hen-treatment groups were significantly different. With the use of an orthogonal test, the rate of egg production among hens given 12.5 mg PCB weekly was found to be no different ($P > 0.05$) from the rate of the control group; but the rate of the 50-mg group was different ($P < 0.01$) from the rates of the other groups.

M. A. Haegele at the Denver Wildlife Research Center (personal communication) found that a single oral dose of 500 mg/kg of Aroclor 1254 given to Japanese quail (*Coturnix coturnix*) reduced egg production about 50 percent for 7 days post-treatment, but that egg production was near normal 8–9 days after treatment.

The differences among treatment groups in egg fertility were significant ($P < 0.05$);

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Table 1. Reproductive statistics from control pheasants and pheasants given PCB.

Treatment Group[a]	No. Eggs per Hen per Day	No. Eggs Set for Incubation	Fertile Eggs		Fertile Eggs Hatched		Fertile Eggs Pipped But Not Hatched	
			No.	Percent	No.	Percent	No.	Percent
0–0[a]	0.621	377	101	36	74	73	6	6
0–12.5	0.459	220	128	58	87	68	29	23
0–50	0.292	136	50	37	32	64	6	16
25–0	0.335	168	91	54	73	80	9	10
25–12.5	0.362	179	71	40	50	70	16	25
25–50	0.198	98	63	64	41	65	10	16

[a] The first number is the weekly PCB level given to cocks; the second, that for hens.

however, a significant ($P < 0.01$) cock-hen interaction indicated these results to be of no biological meaning.

Hatchability was highest in control groups and lowest in groups in which hens had received 50 mg PCB, but the differences tested by chi-square were not significant ($P > 0.05$). Significant differences ($P < 0.05$) in the numbers of eggs that were pipped but not hatched were found among groups. Apparently, the administration of PCB adversely affected the viability of the embryo at the time of hatching. McLaughlin et al. (1963) injected both 10 and 25 mg of Aroclor 1242 into chicken eggs and found only 0–5 percent hatchability, growth retardation, edema, and beak deformities in embryos.

No significant differences ($P > 0.05$) in eggshell thickness using analysis of variance, were noted among treatment groups (Table 2). Eggshells from hatched eggs without membranes, laid by control hens, averaged 0.26 mm ± 0.02 standard deviation, and those from all hen groups receiving PCB averaged 0.23 ± 0.02. Eggshells from unhatched eggs averaged 0.32 mm ± 0.02 for control hens, and 0.31 mm ± 0.02 for hens receiving PCB. Dahlgren and Linder (1970) found the eggshell thickness of pheasants to be unaffected by weekly administration of 17 capsules containing 6 mg dieldrin, a chlorinated hydrocarbon, as is the PCB compound.

Effects on Chick Behavior

From chi-square analysis, it was learned that when chicks were placed on a visual cliff for up to 5 minutes, significant differences ($P < 0.01$) among treatment groups were found in their behavior (Table 3). Among offspring of hens on 50 mg PCB

Table 2. Measurements of eggshells from eggs laid by control pheasants and pheasants given PCB.

Treatment Groups	Weekly Egg Groups 1–7		Weekly Egg Groups 8–18			
	No. Hatched Eggs	Average Thickness Without Membrane (mm)	No. Hatched Eggs	Average Thickness Without Membrane (mm)	No. Unhatched Eggs	Average Thickness With Membrane[b] (mm)
0–0[a]	41	0.25	30	0.24	63	0.38
0–12.5	48	0.24	45	0.23	28	0.31
0–50	19	0.24	12	0.21	37	0.31
25–0	30	0.27	41	0.27	27	0.33
25–12.5	17	0.23	30	0.23	28	0.31
25–50	35	0.23	5	0.24	13	0.30

[a] The first number is the weekly PCB level in mg given to cocks, the second, that for hens.
[b] Unhatched eggs were measured only from weekly egg groups 8–18.

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Table 3. Behavior on the visual cliff of chicks hatched from control pheasants and pheasants given PCB.

Treatment Group	No. That Jumped to Visually Deep Side	No. That Jumped to Visually Shallow Side	No. Not Jumping Within 5 Minutes
0–0[a]	2	35	8
0–12.5	3	42	6
0–50	3	6	5
25–0	5	33	15
25–12.5	5	22	7
25–50	4	5	6

[a] The first number is the weekly PCB level in mg given to cocks; the second, that for hens.

Table 4. Weights and survival of offspring from control pheasants and pheasants given PCB.

Treatment Group	Weight at 6 Weeks (g)	No. of Chicks to Brooder	No. of Chicks Alive After 6 Weeks	Percent Survival
0–0[a]	396	73	49	67
0–12.5	378	84	49	58
0–50	303	29	3	10
25–0	389	72	50	69
25–12.5	403	50	30	60
25–50	344	40	9	22

[a] The first number is the weekly PCB level in mg given to cocks; the second, that for hens.

weekly, 7 jumped to the visually deep side, 11 jumped to the shallow side, and 11 made no choice in the allotted time. This was in sharp contrast to the behavior of all other groups combined, wherein 15 jumped to the deep side, 132 to the shallow side, and 39 made no choice. Similar behavior changes in pheasant chicks hatched from parents given dieldrin were reported by Baxter et al. (1969).

Effects on Chick Weight and Survival

The weights of chicks at 6 weeks of age (Table 4) were tested by analysis of variance. There were no significant differences due to the PCB level given to cocks, and no significant cock–hen interactions ($P > 0.05$). However, chicks hatched from hens given 50 mg PCB were significantly lighter in weight ($P < 0.05$) than those hatched from control hens and from hens given 12.5 mg.

Chick survival was determined for treatment groups during the first 6 weeks of age while chicks were kept in brooders (Table 4). The survival of chicks was not related to whether cock parents received PCB, but chi-square analysis showed that significantly more ($P < 0.01$) deaths occurred among chicks hatched from hens receiving 50 mg PCB. No difference ($P > 0.05$) was found between mortality of chicks hatched from control hens and those hatched from hens given 12.5 mg PCB.

Apparently, 50 mg PCB given weekly to breeding hens was enough to cause a decrease in the weight of their chicks at 6 weeks of age, and to cause an increase in chick mortality between hatching and 6 weeks of age. Administration of PCB decreased egg production and caused an increase in the number of eggs that were pipped but not hatched among treated groups. Behavioral changes, on a visual cliff of newly hatched chicks were also effected by PCB. However, fertility and hatchability of eggs, eggshell thickness, and weekly weights and survival of adult pheasants given PCB were unaffected.

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A NEW STRATIFICATION FOR MOURNING DOVE CALL-COUNT ROUTES

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Abstract. The mourning dove (*Zenaidura macroura*) call-count survey is a nationwide audio-census of breeding mourning doves. Recent analyses of the call-count routes have utilized a stratification based upon physiographic regions of the United States. An analysis of 5 years of call-count data, based upon a stratification using potential natural vegetation, has demonstrated that this new stratification results in strata with greater homogeneity than the physiographic strata, provides lower error variance, and hence generates greater precision in the analysis without an increase in call-count routes. Error variance was reduced approximately 30 percent for the contiguous United States. This indicates that future analysis based upon the new stratification will result in an increased ability to detect significant year-to-year changes.

Management of mourning doves in the United States has been confined essentially to the control of harvest by hunting regulations (Ruos and Tomlinson 1968). To guide the setting of regulations, some measure of the direction and magnitude of annual change in size of population is needed. The call-count survey was developed as a

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