The Effects of Polychlorinated Biphenyl on Longevity of Bobwhite Quail (*Collinus virginianus*): A Sex Differential (37606)

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During experiments (1970–71) on the effect of polychlorinated biphenyl (PCB) on bobwhite quail, within one group of 60 hens and 15 cocks on a diet containing 500 ppm of PCB, three-fourths of the cocks succumbed to the treatment within 1 mo while fewer than one-half of the hens died during the same period. (None of the control birds died during this period.) A search of the literature revealed no information concerning a sex-differential effect of PCB on any species. Reports were found, however, which showed that female robins (1) and female Japanese quail (2) were more resistant to DDT poisoning than were males. The present study was conducted to test the differential effect of PCB on the two sexes.

Experimental Procedure. Two hundred young-adult quail were divided into two equal-sized groups; each group contained approximately 50 hens and 50 cocks. Both groups were housed at the Oklahoma Department of Wildlife Conservation Game Bird Farm, El Reno, OK, in small (about 8 × 10 ft) unheated coops with sand-covered, concrete slab floors. They had access to open air, wire enclosed runs of about the same size. The birds were given feed and water *ad libitum*. The control group received a coturnix ration[1] while the experimental group received the same ration supplemented with PCB[2] at a concentration of 500 ppm. The supplemented ration was prepared by dissolving the PCB in acetone and dripping the solution into the feed while the latter was being mixed. The mixing was continued for 0.5 hr after the solution had been added. The treatment was commenced 26 Oct. 1971. Egg production and death rate for both groups were monitored daily until all of the experimental birds died.

The control birds were then transferred (8 Dec.) to an indoor, heated animal room where they were exposed to 16 hr of light/day. The birds were caged in commercial chick brooders of two sizes, 18 × 34 in. and 30 × 30 in., nine birds/smaller cage and 13 birds/larger cage. The sex ratio in each cage was as near 1:1 as possible. Birds in one small and in one large cage were assigned at random as controls. The remaining birds served as experimentals. All initially received the standard coturnix ration and water *ad libitum*. When the weekly egg-lay reached 2+ eggs/hen/wk, the ration for the experimental birds was supplemented with 500 ppm PCB. This began on 11 Jan. 1972. The daily egg-lay was monitored through the 91st day of treatment and the death rate through 116 days.

In both the October and January experiments, crushed oyster shell was offered twice weekly.

Results and Discussion. October experiment. Under outdoor temperatures during the October experiment, none of the control birds died and birds in neither the control nor the PCB-treated groups laid eggs. The survival rate of the two sexes in the PCB group, expressed as percentage surviving., is plotted against time and is shown in Fig. 1. The curves for the two sexes did not differ

[1] The coturnix ration was prepared by the Oklahoma State University Poultry Science Division, Stillwater.

[2] The PCB used in this experiment was Alcolar (1260) which was kindly supplied by Monsanto, St. Louis, MO.

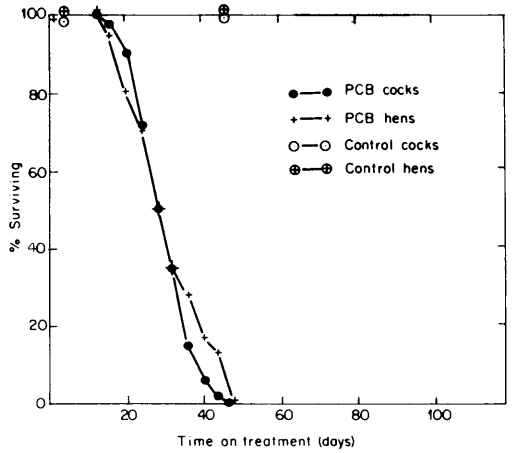

FIG. 1. The effects of PCB (500 ppm in feed) on survival of adult bobwhite quail in a nonbreeding state in unheated aviaries during the fall (Oct.–Dec.) of 1971. The numbers of quail initially present were 54 cocks and 46 hens on PCB and 48 cocks and 49 hens on control feed.

visually in slope or time until near the end of the experiment, Day 32, when the curves appeared slightly different. It was interesting to note that the 50% survival times of the two sexes were identical, 28 days, and that the last cock died only 2 days before the last hen.

From the October experiment it seemed evident that there was no difference between the sexes in regard to resistance to PCB intoxication. However, since the cocks in our experiment of 1970–71 seemed to die earlier than the hens, we decided to test the birds under breeding conditions.

January experiment. During the January experiment none of the control birds died. Figure 2 shows the survival rate of the PCB-fed quail. Several conclusions may be drawn from these data. Note that the 50% survival time for treated birds of both sexes increased (39 days for the cocks and 50 days for the hens) when the birds were in breeding condition and housed in a warm room. Figure 2 also shows that the slope of the survival curve of the hens departed early in the experiment from that of the cocks. Furthermore, while the slope of the survival curve of the cocks remained more or less constant until all cocks had died at 68 days, the slope of the survival curve of the hens leveled out for several weeks before again declining at near its previous rate.

The greater 50% survival time of both sexes in the January experiment as opposed to the October experiment indicates that a more protected environment and/or being in a breeding status enhanced the quail's resistance to PCB toxicity. However, the longer 50% survival time of the hens, coupled with the much longer time required to kill 75% of the hens, 96 days compared with 50 days for the cocks, clearly shows that hens, under these

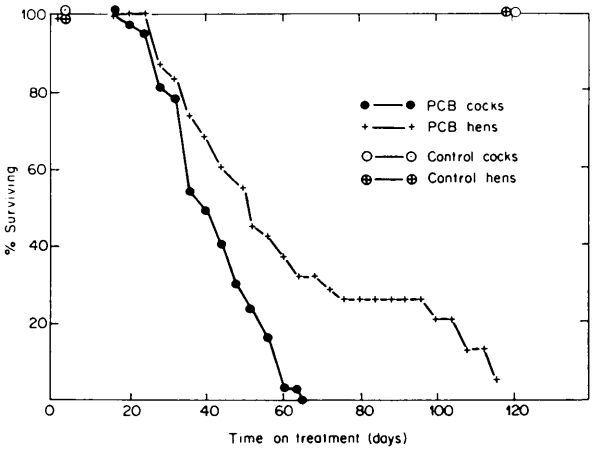

FIG. 2. The effects of PCB (500 ppm in feed) on survival of adult bobwhite quail in the breeding state in a heated building during the winter (Jan.–April) of 1972. The experiment initially commenced with 38 females and 37 males on the PCB supplemented and 11 females and 11 males on the control diet.

conditions, are more resistant to PCB poisoning than are males, and strongly suggests that this resistance is coupled with their being in breeding condition.

Although individual egg-lay records could not be kept (since the birds were caged in groups) daily egg-lay records were maintained for the treated birds as a group and for the controls as a group. The egg production of the PCB-treated quail was significantly lower ($p < 0.005$ using the Student's t test for the difference between paired samples (3)) than that of the controls during the first 56 days, but was well above control levels ($p < 0.025$) during the remainder of the time in which egg-lay records were kept (see Fig. 3). This might be interpreted to mean that the higher egg producers were being selectively spared from the effects of PCB. Although egg records were not kept after day 91, the egg production of the PCB group was very low with only an occasional egg being found after 100 days, the time during which the survival curve (Fig. 2) again declined.

The reduced egg production of the controls after Day 56 is not readily explainable. The eleven control hens laid 305 eggs during the week preceding and the first 56 days of the January experiment. During the remaining 35 days they laid an additional 80 eggs for a total of 385 eggs or 35 eggs/hen. Coleman (5) reported an average egg lay of 52 eggs/hen/season for bobwhite quail in ground cages under outdoor conditions of temperature and light. On the other hand, Baldini, Roberts and Kirkpatrick (6) reported that 3 bobwhite hens (caged with one cock and selected at random) under continual light laid over a period of 35 wk an average of 170 eggs/hen. At the end of this period, and within 1 wk, two of the hens died. The third hen laid an additional 67 eggs during the succeeding 18 wk, at the end of which time she also died. Necropsy of this hen revealed 500+ immature follicles of less than 3 mm size.

Thus, by either standard the hens under our experimental conditions were low egg pro-

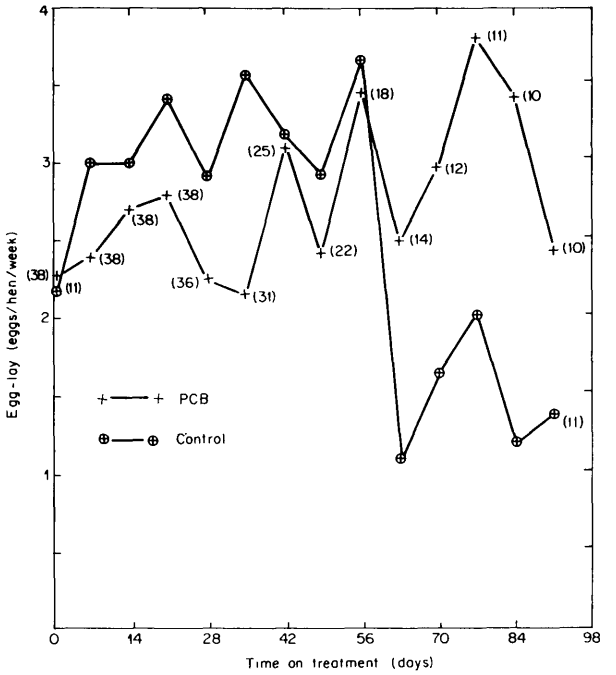

FIG. 3. Egg-lay for bobwhite quail hens receiving 500 ppm PCB in their feed and for hens on control feed for 1 wk prior to treatment which began 11 Jan. 1972 and for the following 13 wk. Numbers in parentheses represent the average number of surviving hens for the week for which the egg-lay is recorded. In all cases there were 11 control hens.

ducers. However, since the controls and PCB-treated quail of our experiment were from the same initial population, the low egg production of the controls during the latter part of the experiment would not necessarily negate the significance of the fact that the longer-lived, PCB-treated quail were better egg producers, as a group, than were the controls, as a group, during the latter part of the experiment.

The possibility does exist that the gradual attrition of the PCB-treated birds due to mortality decreased the population density of these birds and consequently could have enhanced egg production. Coleman (5) pointed out that the seasonal egg lay of individually caged pairs of quail was somewhat greater (65 eggs/hen/season) than that of hens in groups of 12 hens and 4 cocks (52 eggs/hen/season).

The birds of our experiment, it might be pointed out, were confined to cages with wire mesh floors which were elevated above ground level and which contained no nesting material; hardly an ideal nesting site for ground birds.

The mechanism for the greater resistance of breeding female compared to male quail to PCB is not known. In their work with natural populations of robins. Wurster, Wurster and Strickland (1) suggested that males might be more sensitive to DDT than females. Their analysis of body tissue from robins suspected of dying from DDT showed a much greater concentration of pesticide in the females than in the males. Gish and Chura (2) found Japanese quail cocks to be more susceptible to DDT than were females, and that females in breeding conditions were slightly more resistant than females in the nonbreeding state. However, after 10 days on DDT treatment, they found that the mortality of breeding females was similar to that of males and nonbreeding females. Since they were able to show that the heavier quail survived longer than lighter ones when fed DDT and since their breeding female coturnix were heavier than males and nonbreeding females, they indicated that the greater resistance of breeding females was due to the weight difference. They also noticed that hens surviving longest laid the most eggs, and suggested that this too might play a role.

Many investigators have shown that the egg is a mechanism for ridding the body of chlorinated hydrocarbons. Cecil *et al.* (4) found as much as 40% of the ingested dose of DDE to be excreted in the egg of the white leghorn hen.

The quail in our October experiment (nonbreeding state) were not weighed. Twenty of each sex were weighed just prior to commencement of the treatment in the January experiment: the average weight for the hens was 212 g; for the cocks, 190 g.

Data collected at the Oklahoma Game Bird Farm over the past several years on large numbers of young adult quail in a nonbreeding state (about 800 birds/yr for 6 yr) indicate that females weighed about 10 g more than males. It is, therefore, reasonable to assume that female quail in our October experiment were heavier than males, and if body weight alone were the deciding factor, the hens should have survived better than the cocks. However, they did not. In view of this observation, it seems reasonable to attribute the longer 50% survival time of both sexes in the January experiment to a less stressful environment and the greater 50% survival time and much greater 25% survival time of females (vs males) to their being in a breeding state. Furthermore, when the egg-lay is considered, hens that appeared to be better egg-layers were better able to survive PCB feeding than those that were not.

The conclusions drawn from the egg-lay data are tentative and final answers must await experiments in which individual egg-lay records are maintained.

Weekly feed consumption records were maintained for the birds during the January experiment since it was anticipated that PCB-supplemented feed might prove less palatable or that partially PCB-intoxicated birds might eat less feed. That the PCB treatment had little effect on feed consumption during the 9 wk in which feed consumption was monitored is shown in Table I. Therefore, from the feed consumption data it can be concluded that mortality was not due to starvation.

Summary and Conclusions. Bobwhite quail

TABLE I. Feed Consumption of Bobwhite Quail on Normal or PCB-Treated Feed.

Week 1972	Feed consumed (g/bird/wk)	
	Diet containing PCB	Control diet
11–17 Jan.	100 (75)[a]	99 (22)
18–24 Jan.	103 (75)	102 (22)
25–31 Jan.	88 (75)	94 (22)
1–7 Feb.	80 (72)	100 (22)
8–14 Feb.	82 (55)	92 (22)
15–21 Feb.	87 (43)	93 (22)
22–28 Feb.	92 (34)	99 (22)
29–6 Mar.	82 (26)	91 (22)
7–13 Mar.	99 (16)	91 (22)

[a] Number in parentheses = average number of birds alive during the week.

in a nonbreeding status given PCB in their diet at a level of 500 ppm showed no sex difference in survival in outdoor aviaries during the fall (Oct.–Dec.). The 50% survival time of both sexes was found to be 28 days under these conditions. When caged indoors and in a breeding status the 50% survival time of both sexes was prolonged, but the hens lived longer (50% survival time of 50 days) than the cocks (50% survival time of 39 days). Furthermore, 75% of the cocks died within 50 days while it required nearly twice this amount of time (96 days) for 75% of the hens to die.

A comparison of the survival of the female quail with the egg-lay record indicated a positive correlation between survival and egg production. Whether the better survival of the hens in breeding condition is due to excretion of the PCB in the egg, or to some other phenomena is not known.

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1. Wurster, D. H., Wurster, C. F., Jr., and Strickland, W. N., Ecology **46**, 488 (1965).

2. Gish, C. D., and Chura, N. J., Toxicol. Appl. Pharmacol. **17**, 740 (1970).

3. Simpson, G. G., Poe, A., and Lewontin, R. C., "Quantitative Zoology." Harcourt, Brace, Jovanovich, New York (1960).

4. Cecil, H. C., Fries, G. F., Bitman, J., Harris, S. J., Lillie, R. J., and Denton, C. A., Poultry Sci. **51**, 130 (1972).

5. Coleman, W. B., *in* 'The Bobwhite Quail" (H. L. Stoddard, ed.), p. 454. Scribner's, New York (1931).

6. Baldini, J. T., Roberts, R. E., and Kirkpatrick, C. M., Poultry Sci. **33**, 1282 (1954).

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