Lead Toxicity of Bobwhite Quail

by B. L. DAMRON and H. R. WILSON
Department of Poultry Science
Florida Agricultural Experiment Station
Gainesville, Fla. 32611

INTRODUCTION

Lead poisoning of waterfowl and migratory birds may be a problem of wildlife management; however, very limited information is available as to its severity in game birds such as quail (Colinus virginianus), dove (Zenaida macroura), and pheasant (Phasianus colchicus).

DAMRON et al., (1969) reviewed the subject of lead toxicity in waterfowl and also presented evidence that four-week old chickens could tolerate the continuous feeding of 100 p.p.m. lead supplied as lead acetate for a four-week period. They also reported that a level of 1,000 p.p.m. significantly depressed body weight gain. Reports of lead poisoning of quail are very limited in the literature. CAMPBELL (1950) found a dead Scaled quail with 13 lead shot of various sizes in the gizzard and postulated that lead toxicity was the cause of death. WESTEMEHER (1966) made a similar diagnosis in a wild Bobwhite found dead with four shot in the gizzard. STODDARD (1931) reported that a single shot retained in the gizzard with the grinding material was sufficient to cause the death of Bobwhite quail.

Tennessee biologists (LEWIS and LEGLER, 1968) collected almost 2,000 gizzards from mourning doves harvested in fields with an eight-year history of public shooting and found that one percent of the birds had ingested between one and 24 lead shot. Some of the most extensive lead poisoning trials were conducted by MC CONNELL (1967) in which a number of quail and doves of various ages and sexes were force-fed known quantities of lead shot ranging from one to 100 for quail and one to 35 for doves. Nineteen percent of the quail exhibited signs of sickness as compared to 38 percent of the doves with 10 and 32 percent mortality, respectively. Young birds were found to have a higher mortality rate than old birds. The number of shot necessary to cause fatalities was not determined; however, analyses revealed that the average lead level of the blood of quail exposed to lead was approximately 2.5 times the lethal amount for geese.

The present studies were designed to study lead poisoning in quail fed various levels and sources of lead.

[1]Florida Agr. Exp. Sta. Journal Series No. 5486.

Bulletin of Environmental Contamination & Toxicology,
Vol. 14, No. 4 © 1975 by Springer-Verlag New York Inc.

EXPERIMENTS 1 and 2

Procedure

Two experiments of six weeks duration were each conducted with young Bobwhite quail of mixed sex held in floor pens providing 7.43 square meters of floor area. Each pen contained one hanging cylindrical feeder and one bowl-type waterer with dried peanut hulls used as litter. Three replicate pens, each containing 31 and 50 birds in experiments one and two, respectively, were assigned to each of four dietary treatments. The starting age of birds in experiments one and two was six and ten weeks, respectively. In experiment one treatments consisted of 0, 500, 1,000 or 1,500 p.p.m. of supplemental lead. Levels of 0, 1000, 2,000 or 3,000 p.p.m. lead were fed in experiment 2. Water soluble lead acetate was the source of lead added to the basal diet (Table 1) in both experiments. Measurements of body weight gain, feed consumption and mortality served as evaluation criteria.

TABLE 1.

Basal diet composition

Ingredients	Grower (%)	Breeder (%)
Yellow corn meal	62.70	57.50
Soybean meal (49% protein)	30.50	27.00
Fish meal	-----	3.00
Alfalfa meal (20% protein)	3.00	3.00
Animal fat	1.00	1.00
Defluorinated phosphate (18% P; 32% Ca)	1.72	2.51
Ground limestone (38% Ca)	0.08	5.09
Iodized salt	0.40	0.40
Microingredient mix[1]	0.50	0.50
Methionine hydroxy analog	0.10	----
Protein (%)	21.37	21.00
Metabolizable energy (Kcal./Kg.)	3016	2829
Calcium (%)	0.70	3.00
Phosphorus (%)	0.70	0.90

[1]Supplied per kilogram of feed: vitamin A, 6,600 I.U.; vitamin D_3 2,200 I.C.U.; vitamin E, 11 I.U.; menadione dimethylpyrimidinol bisulfite, 2.2 mg.; riboflavin, 4.4 mg.; pantothenic acid, 13.2 mg.; niacin, 59.6 mg.; choline chloride, 998.8 mg.; vitamin B_{12}, 22 mcg.; biotin, .11 mg.; ethoxyquin, 125 mg.; manganese, 60 mg.; iron, 50 mg.; copper, 6 mg.; cobalt, 0.198 mg.; iodine, 1.1 mg.; zinc, 60 mg.

The data were subjected to an analysis of variance (SNEDECOR, 1956) with significant differences among treatment means identified through the multiple range test of DUNCAN (1955).

Results

Neither body weight gain nor daily feed intake was significantly influenced by treatment (Table 2), however, there was a numerical trend towards reduced gain and feed intake for the birds receiving 1,500 p.p.m. of lead. Mortality values were not found to differ statistically. The increased mortality experienced in the 500 p.p.m. lead group was not felt to be related to lead toxicity since much higher levels of lead did not maintain this result. Each increase of dietary lead resulted in a numerical decrease in gain (Table 3), with the highest level, 3,000 p.p.m., producing a slight weight loss which differed significantly from the gains resulting from either the control or 1,000 p.p.m. diets. A significant decrease of daily feed intake was also noted for treatment groups receiving 2,000 or 3,000 p.p.m. lead. Mortality of birds receiving 3,000 p.p.m. was much greater than that experienced with the lower levels of lead supplementation, but due to great variability among replicate pens the difference was not found to be statistically significant.

TABLE 2.

Performance of growing Bobwhite quail receiving various levels of lead in the feed (exp. 1)[1]

Treatment (p.p.m. lead)	Body weight gain (gms.)	Feed/bird/day (gms.)	Mortality (%)
0	61.3	10.4	7.5
500	53.1	10.0	20.4
1000	60.1	10.3	4.3
1500	49.3	9.7	8.6

[1]Six through twelve weeks of age.

TABLE 3.

Performance of growing Bobwhite quail receiving various levels of lead in the feed (exp. 2)[1]

Treatment (p.p.m. lead)	Body weight gain[2] (gms.)	Feed/bird/day[2] (gms.)	Mortality (%)
0	23.3^{a}	13.3^{a}	16.7
1000	18.7^{a}	13.5^{a}	17.3
2000	10.7^{ab}	12.3^{b}	19.3
3000	-1.5^{b}	11.8^{b}	46.7

[1]Ten through sixteen weeks of age.
[2]Means bearing superscripts without common letters are significantly different ($P<0.05$) according to Duncan's multiple range test.

EXPERIMENT 3

Procedure

Since from one-half to six and one-half percent antimony is normally added to increase shot hardness (WAITE, 1973), this experiment was designed to determine the influence of levels of dietary antimony similar to those incorporated into lead shot, as well as the effects of feeding lead acetate, powdered lead and lead shot. The seven dietary treatments employed were - 0, 1,000 or 2,000 p.p.m. lead from both powdered lead and lead acetate, five lead shot (size eight) given orally once each week and antimony at levels of three and six percent (by weight) of the shot dosage. The lead shot were counted out in advance and dropped into the crop by way of a small plastic funnel.

Ten Bobwhite quail (10 weeks of age) of mixed sex were randomly assigned to each of three replicate groups receiving a dietary treatment (210 birds total). All treatment groups were housed in electrically heated Petersime battery brooders with raised wire floors for the six-week experimental period. Final body weights, daily feed intake and mortality served as evaluation criteria.

Results

Body weights were not significantly influenced by treatment (Table 4). The results with reagent lead sources (lead acetate and powdered lead) were somewhat in contrast to those of experiments one and two where numerical reductions in body weight were noted at the 1,500 and 2,000 p.p.m. levels. Daily feed consumption of birds receiving shot was significantly less than controls or any other dietary treatment. Although mortality values were higher in the 2,000 p.p.m. lead acetate and lead shot treatments, no significant differences were found. The elevated value associated with the high-lead acetate treatment may have been partially due to cannibalism in one replicate pen.

TABLE 4.

Body weight, feed consumption and mortality of quail fed lead from three sources or antimony (exp. 3).

Treatment	Av. body wt. (gms.)	Feed/day[1] (gms.)	Mortality (%)
Control	168.4	14.3^{ab}	0
1000 p.p.m. (Lead acetate)	171.1	14.5^{a}	0
2000 p.p.m. (Lead acetate)	170.0	14.3^{ab}	13
1000 p.p.m. (Powdered lead)	163.7	14.3^{ab}	3
2000 p.p.m. (Powdered lead)	171.3	14.3^{ab}	3
3% antimony[2]	168.7	14.3^{ab}	0
6% antimony[2]	171.4	14.0^{b}	0
5 lead shot/week	163.8	13.4^{c}	10

[1] Means bearing superscripts without common letters are significantly different ($P < 0.05$) according to Duncan's multiple range test.
[2] Expressed as a percent of five lead shot.

The results with reagent lead sources (lead acetate and powdered lead) were somewhat in contrast to those of experiments one and two where numerical reductions in body weight were noted at the 1,500 and 2,000 p.p.m. levels. Daily feed consumption of birds receiving shot was significantly less than controls or any other dietary treatment. Although mortality values were higher in the 2,000 p.p.m. lead acetate and lead shot treatments, no significant differences were found. The elevated value associated with the high-lead acetate treatment may have been partially due to cannibalism in one replicate pen.

EXPERIMENT 4

Procedure

Three replicates of six adult Bobwhite cocks housed individually in wire cages received one of the treatment diets for eight weeks. The treatments consisted of a quail breeder diet (Table 1) with the addition of either 0, 500, 1,000 or 1,500 p.p.m. lead in the form of lead acetate. Mortality, feed consumption and body weight were recorded. Semen samples were collected after eight weeks of treatment. Semen was collected from individual birds in capillary tubes of known diameter and the volume calculated. Samples were then pooled within each replicate for concentration, motility and percent dead cell evaluations. Sperm motility was

TABLE 5

Body weight, feed consumption and semen characteristics from Bobwhite given feed containing lead for eight weeks (exp.4).

reatment p.p.m. lead)	Body wt. (gms.)	F/B/D (gms.)	Sperm conc. (b./cc.)[1]	Semen vol.(cc.)	Sperm viability % Dead	Motility[2]
0	187	15.1	11.0	.094	6.7	5.3
500	187	16.0	9.0	.155	6.0	5.7
1000	185	16.8	10.6	.152	3.3	6.0
1500	185	15.7	11.3	.121	7.0	6.0

[1] Concentration expressed as billion cells per c.c. of semen.

[2] Scored by microscopic examination according to the following scale: 1, no cells motile; 2, few isolated cells motile; 3, less than half of cells motile; 4, more than half of cells motile; 5, all cells motile; 6, all cells motile and swirling.

scored on a scale of one to six with one being no cells motile and six being all cells motile and swirling. Dead spermatozoa were identified with the trypan blue wet-mount method (WILSON et al., 1969). Sperm concentration was determined with an electronic particle counter (WILSON and HOLLAND, 1971). Five birds from each treatment were killed and examined at the end of the experiment and the weight of various organs determined.

Results

Treatment had no significant effect on mortality, body weight, semen quality or average feed consumption per bird per day (Table 5). There was a numerical trend for liver and gizzard weights to be increased and testes weight decreased by lead feeding (Table 6); however, these differences were not significant.

TABLE 6.

Organ weights of Bobwhite fed lead in the diet (exp. 4)

Treatment (p.p.m. lead)	Organ wt. (% of body wt.) Heart	Liver	Testes	Gizzard	Body wt. (gms.)
0	.51	1.63	.59	2.12	175
500	.46	2.26	.37	2.41	191
1000	.44	1.81	.43	2.54	183
1500	.49	1.88	.32	2.50	184

EXPERIMENT 5

Procedure

The effects of the ingestion of various levels of commercial lead shot upon the performance of adult male Bobwhite quail were studied in this 28-day experiment. Six individually caged adult birds were randomly assigned to each of two replicate groups receiving a dietary treatment (12 birds per treatment). The five oral dosing treatments employed were: control, five shot once per week, five shot three times per week, ten shot once per week and ten shot three times per week. Shot were of number eight size and administered into the crop through a small plastic funnel. Control birds were also sham treated with the same methodology, and all birds were handled three times per week. Body weight changes, feed intake and mortality served as evaluation criteria. All birds were necropsied, either as mortality during the experiment or after being dispatched at the end of the experiment. Shot recovered from the intestinal tract during necropsy were weighed to determine the degree of erosion within the bird's digestive tract.

Results

Although rather consistent numerical differences were present, only mortality was significantly related to treatment (Table 7).

TABLE 7.

Body weight, feed consumption and mortality of adult Bobwhite cocks dosed with lead shot (exp. 5).

Treatment (No. Shot/Frequency)[1]	Body wt. gain (gms.)		Daily Feed Intake	Mortality[2]
	2 wk.	4 wk.	(gms.)	(%)
Control	- .2	- .1	12.1	8.0[a]
5/1	- 2.1	-17.8	9.2	8.0[a]
5/3	-19.3	-27.5	8.4	58.3[b]
10/1	-27.5	-22.1	7.6	66.7[b]
10/3	-35.8	-15.0	7.4	91.7[b]

[1] Dosings per week

[2] Means bearing superscripts without common letters are significantly different ($P < 0.05$) according to Duncan's multiple range test.

The intake of any lead shot over the four-week feeding period resulted in numerical weight loss. The average weight loss, daily feed intake and mortality values for birds receiving either five shot three times per week or 10 once per week were approximately the same. Weight loss of birds receiving 10 shot three times weekly was not as severe at the end of the period because most of the birds had died; however, it was the most severe of all

treatments at the midpoint of the experimental period. Mortality of the five/one group did not differ from that of controls, but that of the other treatments was significantly greater and did not differ from each other statistically. Average weights of shots recovered from various portions of the digestive tract and feces of birds were as follows: crop - 71.2 mg., gizzard - 56.4 mg. and feces - 51.5 mg. Average weights of fecal shot were approximately 71 percent of a stock sample.

SUMMARY

Five experiments were conducted involving both juvenile and adult Bobwhite quail (Colinus virginianus) to study the toxicity of lead acetate, lead shot, powdered lead and antimony. Performance of juvenile birds receiving up to 1,500 p.p.m. of lead as lead acetate was not significantly influenced during the six-week experimental period. Feeding 3,000 p.p.m. lead as lead acetate was not significantly influenced during the six-week experimental period. Feeding 3,000 p.p.m. lead as lead acetate was associated with a significant depression of body weight and an increase in mortality.

Feeding growing quail up to 2,000 p.p.m. lead from either lead acetate or powdered lead, 3 or 6% antimony (as % of shot dosage) or 5 lead shot per week caused no significant effects upon either body weight or mortality.

No significant trends were noted in body weight, feed intake, semen quality or organ weight of adult quail that received up to 1,500 p.p.m. lead from lead acetate. Dosing adult Bobwhite quail cocks with 10 or more lead shot per week caused a significant increase in mortality, and more than 90% of those dosed with 30 shot per week died by the end of four weeks.

LITERATURE CITED

CAMPBELL, H., J. Wildlife Management. 14(2), 208 (1950).
DAMRON, B. L., C. F. SIMPSON and R. H. HARMS, Poultry Sci. 48, 1507 (1969).
DUNCAN, D. B., Biometrics. 11, 1 (1955).
LEWIS, J. C. and E. LEGLER, JR., J. Wildlife Management 32, 476 (1968).
MCCONNELL, C. A., Proceedings of the 31st Annual Conf. S.E. Assoc. of Game and Fish Commissioners. p. 208 (1967).
SNEDECOR, G. W., Statistical Methods, 5th edition. Ames, Iowa, Iowa State University Press 1956.
STODDARD, H. L., The Bobwhite Quail, Its Habits, Preservation an Increase. New York, Charles Scribner's Sons, p. 559 1931.
WAITE, M. D., The American Rifleman. 121(1), 38 (1973).
WESTEMEHER, R. L., The Wilson Bulletin. 78, 471 (1966).
WILSON, H. R. and M. W. HOLLAND, JR., 68th Proc. Assoc. So. Agr. Workers, Inc. p. 217 (1971).
WILSON, H. R., A. C. WARNICK and J. H. GUTIERREZ, Poultry Sci. 48, 714 (1969).