Bull. Environm. Contam. Toxicol. 29, 177–183 (1982)

Influence of Lead Acetate or Lead Shot Ingestion upon White Chinese Geese[1]

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The incidence of waterfowl mortality due to lead poisoning has been a controversial subject for many years. In Wisconsin, from 1940 to 1963, there were 1779 Canadian geese deaths suspected of being due to lead poisoning, however, only 576 of these cases were laboratory confirmed. During the same time period, only 20 of 215 wild duck deaths were confirmed as lead poisoning (TRAINER and HUNT 1965).

Experimental dosing of Canadian geese by COOK and TRAINER (1966) resulted in all birds dying that received 5 or more number 4 lead shot. All mallard ducks dosed with 8 number 6 lead shot died within 15 days. Ducks dosed with alloy shot (60% tin, 40% lead) or zinc shot had mortality rates of 27% and 20%, respectively. Hemosiderosis of the liver was present in almost every bird examined (GRANDY et al. 1968).

The feeding of 1000 ppm lead from lead acetate caused reduced body weight gains in 4-week old broiler chicks, but 100 ppm had no effect on growth in experiments by DAMRON et al. (1969). The dosing of adult Bobwhite quail cocks with 10 or more number 8 lead shot per week caused significant increases in mortality, and greater than 90% of the birds dosed with 30 lead shot per week died by the end of 4 weeks. Dosing with 5 shot weekly did not influence mortality (DAMRON and WILSON 1975).

A number of reports have indicated that the type and texture of diet being consumed by waterfowl during the period of shot ingestion was related to the severity of lead toxicity symptoms. IRBY et al. (1967) dosed pen-reared mallards receiving whole corn diets with 8 number 6 lead shot. Three deaths resulted among the 24 birds dosed, and all exhibited marked hemosiderosis of the liver. JORDAN and BELLROSE (1951) compared whole and ground corn with the conclusion that corn meal reduced lead's toxic effects, while HOLMES (1975) did not find these differences from similar studies to be significant. Earlier, JORDAN and BELLROSE (1950) reported that no mortality occurred in adult mallards given 1 number 6 lead shot and fed mixed grains along with aquatic plants. Mallards that

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[1] Florida Agricultural Experiment Stations Journal Series No. 3138.

0007-4861/82/0029-0177 $01.40
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received the mixed grains alone exhibited 70% mortality. This study and an additional experiment with wild mallards fed a diet composed totally of seeds obtainable in nature provided a basis for the conclusion that ducks on a seed diet were more susceptible to lead poisoning than those on a diet supplemented with green, leafy plants.

The objectives of this study were to examine the effects of lead shot, various levels of lead acetate, or diet on the health and livability of White Chinese geese.

METHODS

Two experiments were conducted to determine the effects of lead source or diet composition in relation to lead poisoning in geese. In the first experiment 36 male and 36 female, 26-week old, White Chinese geese were housed in modified Oakes finishing batteries with raised wire floors. The birds were vent sexed and 2 pens of each sex (3 birds/pen) received each of 6 dietary treatments. Feed and water were given ad lib., and lighting was continuous for a 12-week feeding period.

Dietary treatments consisted of a corn-soy basal diet (Table 1) which supplied all nutrient requirements for geese as recommended by the National Research Council.

Table 1. Basal diet composition

Ingredients	% of Diet
Yellow corn	72.00
Soybean meal (48.5%)	19.00
Limestone (38% Ca)	5.65
Dicalcium Phosphate (22% Ca; 18.5% P)	1.98
Salt	0.52
Microingredient mix*	0.65
DL-Methionine	0.21

*Supplied the following activities per kg of diet: vitamin A, 8448 IU; vitamin D_3, 2816 ICU; menadione dimethyl-pyrimidinaol bisulfite, 16.9 mg; niacin, 50.7 mg; choline chloride, 639.2 mg; vitamin B_{12}, 28.2 mcg; ethoxyquin, 0.016%; manganese, 76.8 mg; iron, 64 mg; copper, 7.7 mg; cobalt, 0.253 mg; iodine, 1.4 mg; zinc, 44,8 mg.

This diet was supplemented with lead acetate to provide 500, 1000, 1500, or 2000 mg of lead per kg of diet for the entire experimental period. The sixth treatment was oral doses of commercial lead shot. Each bird was administered number 8 shot at a rate of 5 shot

twice weekly for 4 weeks, and then 10 shot weekly for 8 additional weeks. A pyrex funnel with a 15 cm stem, 0.75 cm in diameter, was inserted into the esophagus of the bird, and the lead shot was then poured into the funnel.

At the end of the feeding period, selected birds were sacrificed by cervical dislocation and the livers examined for signs of abnormalities. Gizzards were also dissected and observed for the presence of whole or partially eroded shot.

In the second experiment, 105 mixed sex, 28-week old White Chinese geese were housed in individual broiler breeder cages where feed and water was given ad lib. Three replications (5 birds/replicate) were assigned to each of 6 dietary treatments for a 6-week feeding period.

Experimental treatments were arranged in a 2 x 3 factorial design with lead shot dosing (5 number 8 shot twice weekly) being one of the treatment variables. The second variable was the type of diet given. The 3 dietary variables were whole yellow corn, ground yellow corn or a mixture of ground yellow corn (59.3%), alfalfa leaf meal (40%) and a turkey vitamin mixture (.7%).

At the termination of the feeding trials, 2 birds from each replicate pen were sacrificed and samples of liver and the right tibia removed and analyzed for lead content using a Perkin-Elmer Model 360 Atomic Absorption Spectrophotometer.

For both experiments, starting individual body weights were recorded and body weight gains were determined on a bi-weekly basis. Daily feed consumption was calculated on a weekly basis. Mortality was recorded on a daily basis, and all data were analyzed using analysis of variance (SNEDECOR 1956) and Duncan's multiple range test procedures (DUNCAN 1955).

RESULTS

Experiment One:

Body weight gains (Table 2) were not significantly depressed by any level of lead acetate or shot addition. Geese that received regular doses of lead shot gained more weight than any other experimental group. Daily feed intake over the experimental period (Table 2) was also not significantly influenced by treatment. Feed intake was greatest for birds that were dosed with lead shot. The only mortality ocurring during the experiment was 1 bird lost from each of the control, 1000 mg/kg lead, and 2000 mg/kg lead treatments. These losses resulted from birds wedging their heads between the bars of the batteries and severely injuring their jaws.

Table 2. Daily feed intake and body weight gains of geese fed lead acetate or oral doses of lead shot (Experiment 1).

Treatment	Av. body wt. gain (g)			Daily feed intake (g)		
	Male	Female	Av.	Male	Female	Av.
Control	625	566	596	224	203	214
500 mg/kg Pb	646	646	646	207	224	216
1000 mg/kg Pb	512	643	578	223	225	224
1500 mg/kg Pb	718	569	644	231	243	237
2000 mg/kg Pb	416	721	569	207	237	222
Lead shot*	835	605	720	263	236	250

*Number 8 shot were given orally at a rate of five shot twice weekly for four weeks, then increased to ten shot twice weekly for eight additional weeks.

Autopsies revealed no gross physiological abnormalities in any of the birds. Livers from birds fed the high level of lead or from those dosed with lead shot, were enlarged and had a yellowish discoloration when compared to livers from control birds.

Shot in various stages of erosion was found in the gizzards of the dosed birds. Shot size ranged from full-size to particles smaller than sand. The gizzard lining had a distinct dark grey coloring due to the erosion of the lead shot. In contrast, the gizzard lining from birds fed 2000 mg/kg lead from lead acetate had no abnormal discoloration.

Experiment 2:

In no case was there a significant difference among body weight gains due to lead shot dosing of birds receiving the same diet (Table 3). Birds fed on the ground corn or a combination of ground corn and alfalfa showed a numerical improvement in body weight gains when receiving lead shot. In contrast, geese that received whole corn lost weight when doses of lead shot were applied. This variation in body weight gain among the dietary treatments with lead shot dosing resulted in a statistically significant interaction between diet and lead exposure.

Table 3: Body weight gains, daily feed intake and mortality of geese fed various diets and dosed with lead shot (Experiment 2).

Dietary treatment	Body wt.* gains (g)	Daily feed* (g)	Mortality (total deaths)
Whole corn	322.6 ab	133.6 b	1
Whole corn + Pb shot	-51.8 ab	123.8 b	2
Ground corn	284.4 ab	207.4 a	0
Ground corn + Pb shot	412.9 a	198.0 a	0
Ground corn + vit. + alfalfa	-149.6 b	191.0 a	0
Ground corn + vit. + alfalfa + Pb shot	-36.0 ab	220.5 a	0

*Means in the same column without common letters are significantly different ($P < .05$) according to Duncan's multiple range test (1955).

Geese receiving 40% alfalfa in the diet lost weight over the six-week period whether they were dosed with lead shot or not. The weight loss was numerically more severe for the group without lead. This body weight loss is thought to be due to the saponin content of alfalfa. PEDERSON et al. (1972) reported that 10% alfalfa meal in the diets of chicks reduced body weight gains and decreased feed efficiency.

Daily feed intake (Table 3) was not significantly affected by administration of lead shot. Birds receiving whole corn had a significantly lower feed intake than birds receiving ground feed. This may be due to the sudden change in the form of diet, since the birds were raised on a mash-type diet. Observations showed that these birds were "confused" with the presentation of whole corn and were unsure of how to eat it.

Mortality was not significantly affected by treatment (Table 3). Only 3 birds were lost in the entire 6-week period and it is felt that some of these deaths were caused by the birds' inability to consume whole corn.

There was a significant increase in lead content of both liver and bone for any treatment receiving doses of lead shot (Table 4). The highest level of lead was found in birds that were fed ground corn.

Table 4. Analyses of liver and tibia from geese fed various diets and dosed with Pb shot.

Dietary treatment	Lead* (ppm) Liver	Bone
Whole corn	.0[a]	3.0[a]
Whole corn + Pb shot	34.4[b]	542.4[bc]
Ground corn	.0[a]	2.0[a]
Ground corn + Pb shot	34.5[b]	637.7[cd]
Ground corn, alfalfa and vitamins	.6[a]	4.5[a]
Ground corn, alfalfa, vitamins, and Pb shot	31.2[b]	516.4[b]

*Means in the same column without common letters are significantly different ($P < .05$) according to Duncan's multiple range test (1955).

Conclusions

In experiment 1, the feeding of various levels of lead acetate or lead shot to White Chinese geese did not significantly affect daily feed intake or body weight gains. No mortality could be attributed to lead poisoning. Examination of liver samples showed a slight increase in size and a yellow discoloration for birds fed 2000 mg/kg lead or dosed with lead shot.

It is thought that lead shot ingested by waterfowl is retained in the gizzard and that part of it is ground down and absorbed into the body. The geese in the first study were dosed with a total of 200 shot over a 12-week period with no deaths resulting. This is contradictory to many studies where one dosing of only 4 to 8 shot caused deaths in a short period of time.

In experiment 2, dosing of geese with lead shot did not significantly affect body weight gains as compared to undosed birds on the same dietary treatment. Daily feed intake was not affected by lead dosing, but whole corn diets caused a significantly lower feed intake than mash diets.

Analysis of liver and bone for lead content show a definite accumulation of lead in these tissues. Although the birds exhibited no outward signs of illness it is thought that a longer feeding is required to determine if there may be long term toxic effects of lead ingestion.

It is the authors opinion that the difference between many earlier reports involving field studies and these trials may be due to other factors, possibly nutrition, since birds in part of this study were receiving a complete diet. We tend to agree with JORDAN and BELLROSE (1950) in that the nature of the diet rather than ingestion of lead shot is the most important variable in the study of lead poisoning in waterfowl. It seems likely that the borderline plane of nutrition provided by the reduced intake of a whole grain when coupled with the stress of lead shot ingestion may produce a field condition in geese and ducks that would be more severe than either factor alone.

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Accepted May 24, 1982