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Effects of Lead Shot Ingestion in Willow Grouse

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Willow grouse (Lagopus lagopus) is the most popular game bird in Norway and hunted extensively. Ingestion of lead shot pellets as grit with consequently adverse effects is therefore a distinct possibility as this has been observed in other upland game birds such as ring-necked pheasant (Phasianus colchicus) (Hunter and Rosen 1965), bobwhite quail (Colinus virginianus) (Westemeier 1966), and mourning doves (Zenaida macroura) Locke and Bagley 1967). The present experiment was carried out to study the possible effects of ingested lead shot pellets on willow grouse.

MATERIALS AND METHODS

The birds used in the present study were raised at the Wildlife Biology Station, University of Tromsø. They were two months old at the start of the experiment and then weighed 530 g on average. Before and during the experiment they were fed ad libitum a standard grouse ration (a modification of a commercial chicken feed) supplied with blueberry plants (Vaccinium myrtillus) and oak fern (Gymnocarpium dryopteris). The birds were kept separately in cages but such that pairs had visual contact through a wire netting wall. The cage floor was made of wire netting so that the feces could be collected for investigation of expelled lead pellets.

The birds were divided randomly into four groups of nine each. One group served as a control while the other three were given one, three, and six lead pellets (Eley no. 6), respectively. The pellets were weighed to the nearest mg and introduced into the crop through a soft rubber tube. Observations on behavior and food consumption were conducted daily. Every second day feces were collected and examined for expelled lead pellets. These pellets and those taken from the gizzard of dead birds were washed, dried and weighed. The birds were weighed every third or fourth day.

Samples for histologic examinations were taken from kidneys, liver, breast muscle, spleen, colon, small intestine, spinal cord, and brain and fixed in 10 per cent formalin. Samples of breast muscle, liver, and femur bone were analyzed for lead by atomic absorption spectrophotometry. They were stored frozen until analysis took place.

RESULTS AND DISCUSSION

Within a few days of dosing the food consumption became radically reduced by all nine birds that had ingested six lead pellets and by four of those that had ingested three pellets. These birds emaciated rapidly. Their feces became dark green and bile stained and they exhibited overt symptoms of lead poisoning by appearing very dull and unthrifty. Four of them (two in each group) ceased eating completely and died within 8-15 days when their body weight had been reduced by 35-54 per cent.

The breast muscle and liver lead concentrations in the dead birds with two or three shot remaining in the gizzards, varied from 0.9 - 2.6 and 64-274 ppm (wet weight), respectively while the ashed femur bones contained 214-264 ppm (dry weight) of lead (Table 1).

The amounts of eroded lead were calculated to be 85 and 177 mg for the birds that had received three shot and 238 and 268 mg for those receiving six shot. Histologic examinations of breast muscle, liver, kidney, spleen, intestines, spinal cord, and brain revealed no significant lesions in there tissues. The keratinized lining of the gizzard, however, was much fragmented and for one of the birds stained blackish green.

In surviving birds a temporary weight reduction took place in all dosed groups (Table 2). The reduction was greatest with increasing lead dose. When or shortly before the last lead pellet had been voided, (an average of 5, 10 and 13 days for the groups of which each bird had been given 1, 3 and 6 lead pellets, respectively) they began regaining weight rapidly. Even those birds that had exhibited signs of lead poisoning, but survived, apparently recovered completely although, based on the figures for eroded lead, many of these had been exposed to considerably more lead than two of those that succumbed (Table 3).

From Table 3 it can be seen that only the most heavily dosed birds accumulated significant levels of lead in the breast muscle while clearly elevated levels in liver and femur bone were registered in all lead exposed birds.

Table 1. Weights of, and lead concentrations at death in, experimentally lead poisoned willow grouse

No. of lead pellets ingested	No. of lead pellets in gizzard at death	Days until death	Body weight at start of exp.	Body weight at death	Lead concentrations (ppm) wet weight Breast muscle	Lead concentrations (ppm) wet weight Liver	Lead concentrations (ppm) dry weight Femur
3	3	8	516	337	0.9		214
3	2	11	544	338	3.0	64	264
6	4	9	512	277	0.8	134	226
6	2	15	560	258	2.6	274	224
0	-	a	535	587	<0.1	<0.1	4.7
0	-	a	603	610	<0.1	<0.1	2.8

a: The control birds were sacrificed 23 days after the experiment started.

Table 2. Mean interval weight gains (+) or losses (-) (grams) of willow grouse following ingestion of lead shot pellets (the weight of the four birds that died are not included).

No. of pellets ingested	N	Number of days from start of experiment 3	7	10	15	23
0	9	+22	+ 6	+ 4	-11	+16
1	9	0	- 11	+16	- 2	+ 8
3	7	-22	- 60	+18	+ 8	+35
6	7	-37	-109	+10	+29	+59

However, in sacrified birds the liver lead levels were substantially lower than those similarly dosed birds that succumbed. After the last shot had been voided the lead concentrations in the lover were reduced radically within two weeks but not in muscles and femur bones (Table 3).

Table 3. Mean lead concentration in breast muscle, liver, and femur bones of willow grouse as a function of ingested lead and elapsed time following the expulsion of the last pellet.

No. of days start of exp.	No. lead pellets ingested (n)	Lead concentrations (ppm) Wet weight Breast Muscle	Liver	Dry weight Femur	Eroded lead (mg)
15[a]	1(2)	<0.1	3.2	77	47
	3(2)	<0.1	7.3	192	129
	6(2)	0.7	72	213	257
	Contr. (2)	<0.1	<0.1	3.1	-
33[b]	1(2)	<0.1	2.1	55	75
	3(2)	<0.1	2.2	112	159
	6(2)	0.5	7.6	226	222
	Contr. (2)	<0.1	<0.1	4.3	-
150	1(3)			50	73
	3(3)			183	98
	6(3)			246	160
	Contr. (2)			5	-

a: 5-10 days after the last pellet was expelled
b: 20-28 days after the last pellet was expelled

This experiment revealed that three no.6 lead shot are sufficient to cause death from lead poisoning in willow grouse. The liver lead levels, that according to Longcore (1974), Pattee et al. (1981) and the present study, is a useful criterion for diagnosing lead poisoning in birds, were then 64-274 pp. This is very high when compared to other findings on the lead concentrations in liver associated with death. In waterfowl such concentrations are reported to be 5-109 ppm (Chupp and Dalke 1964, Longcore et al. 1974, Anderson 1975), in raptors 11.5.-38.5 ppm (Locke et al. 1969, Mulhern et al. 1970, Pattee et al. 1981), and in pheasants 168 ppm (Hunter and Rosen 1965).

Although the present findings accordingly could suggest that the willow grouse is more tolerant to lead poisoning than most bird species the strong individual variation in susceptibility that is apparent from this and the above studies warrants no such conclusion. However, the minimum liver lead levels of 64 ppm in succumbed birds and the maximum of 115 ppm in survivors suggest that concentrations in that range make lead poisoning a probable mortality factor in willow grouse. My findings further indicate that the quantity of the initial lead ingestion may have influence on what will be the critical concentrations. When considering the ecological significance, however, it should be taken into account that birds held in captivity often react differently to toxic chemicals than do wild birds as secondary factors such as starvation, disease, predation, and exposure to various climatic conditions can alter the susceptibility.

In breast musculature the present residue levels, ranging from 0.9-3.0 ppm in birds that died, are considerably less than the 42 ppm reported from a naturally lead poisoned pheasant (Hunter and Rosen 1965) but in the same range as those found in experimentally dose-killed bald eagles (Haliaeetus leucocephalus) (Pattee et al. 1981). According to Pattee et al. (1981) muscle lead levels are generally lower in experimentally poisoned birds than in comparable field samples, a difference that is probably related to different exposure patterns. Concentrations in breast muscles in the present report should therefore not be taken as a reliable indicator of lead poisoning in willow grouse. The femur concentrations varied little among the succumbed birds (214-264 ppm) and reached approximately the same levels as in survivors of the group that had ingested 6 lead shot. These levels did not decrease during the 150 days experimental period. Accordingly, femur bone concentrations above 200 ppm (dry weight) indicate lead poisoning in willow grouse.

Bone lead levels associated with poisoning in mourning doves (Locke and Bagley 1967) were of the same order but were considerably lower in bald eagles (Pattee et al. 1981).

The emaciated birds that survived gained weight very quickly after expulsion of the last lead shot, even those that had accumulated liver lead levels above 70 ppm. This must be taken as an indication of a lack of serious permanent injury to the birds, a finding that also is in accordance with the absence of histopathologic damage to vital organs. The present investigations did not include ultrastructural observations, and more subtle histologic effects can therefore not be excluded as such effects are common in lead exposed birds (Kendall et al. 1982).

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