Ingested lead pellets in waterfowl at the Ouse Washes, England, 1968–73

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Introduction

Lead poisoning has been known amongst waterfowl for more than a century and much of the available literature has been reviewed by Olney (1960). Lead pellets fall on to the substrate and may subsequently be ingested by waterfowl when they are feeding or taking grit. Most are retained in the gizzard until they are ground down. The lead forms compounds with the digestive juices and may be circulated in the blood stream and become deposited in the liver, kidneys, bones, nerves and muscles of the bird. One of the first visible symptoms, noted in captive birds, is a marked lethargy. Within two days of ingesting a lead pellet birds may begin to produce bright green droppings. Field experiments by Bellrose (1959) indicate that Mallard *Anas platyrhynchos* dosed with lead pellets are either shot or die of lead poisoning in the second or third week following ingestion or begin to recover by the fourth week. The dosed Mallard appeared to be afflicted for about 15 days, their movements being greatly reduced, and were more likely to be shot than were unaffected birds. Post mortem features include a reduction in the size of flight muscles, flabby heart muscles, enlarged gall bladder, an excessive secretion of bile into the duodenum and an atrophy of gizzard muscles.

Materials and methods

From 1968 to 1973, as part of a feeding study, guts were examined from birds shot by wildfowlers at the Ouse Washes in Cambridgeshire and Norfolk. The gizzards from 1,250 waterfowl of 11 species were examined as to their general appearance and to see whether or not they contained lead shot. Six gizzards, all of Mallard, which showed signs of pellets having been fired into them were discarded from further analysis.

Incidence of lead pellets in gizzards of waterfowl

Table 1 compares the incidence of lead pellets in the gizzards of waterfowl shot at the Ouse Washes with those reported from North America (Bellrose, 1959) and Britain (Olney, 1960, 1968). The frequency of pellets in the dabbling ducks in similar in all three studies. Lead pellets were found in 9% of the 380 Mallard from the Ouse Washes which is not a significant increase on the 6·6% in 244

Table 1. Incidence of lead pellets in the gizzards of waterfowl.

	North America 1938–1953 (Bellrose 1959)			Britain 1957–1959 (Olney 1960, 1968)			Ouse Washes 1968–1973 (Present study)		
Species	Number examined	No. with lead pellets	% with pellets	Number examined	No. with lead pellets	% with pellets	Number examined	No. with lead pellets	% with pellets
Mallard *Anas platyrhynchos*	17066	1159	6·8	244	16	6·6	380	34	9·0
Pintail *Anas acuta*	4530	402	8·9				89	9	10·1
Shoveler *Anas clypeata*	1439	23	1·6	14	1	7·1	102	2	2·0
Teal *Anas crecca*	2272	31	1·4	277	0	0·0	278	9	3·2
Gadwall *Anas strepera*	1141	21	1·8				25	0	0·0
Wigeon *Anas penelope*							220	0	0·0
Tufted Duck *Aythya fuligula*							26	0	0·0
Lesser Scaup *Aythya affinis*	886	116	13·1						
Pochard *Aythya ferina*				45	4	8·8	21	0	0·0
Redhead *Aythya americana*	579	81	13·6						
Moorhen *Gallinula chloropus*							32	2	6·3
Coot *Fulica atra*							10	0	0·0
Snipe *Gallinago gallinago*							67	1	1·5

Figure 1a. A radiograph of a Bewick's Swan showing 4 lead pellets (arrowed) among gizzard grit.

Figure 1b. The 4 eroded pellets extracted from the dissected gizzard.

examined by Olney for Britain. He recorded no pellets in his sample of 277 Teal *Anas crecca* whilst pellets were recorded in 3·2% of the 278 Teal from the Ouse Washes, a significantly higher proportion (Fisher's Exact Probability Test $p = 0{\cdot}002$).

Pintail *Anas acuta* and Mallard have the highest incidence of lead pellets in their gizzards. These species commonly grub about 6 cm into the bottom layers of water bodies, where they are likely to come into contact with the used lead pellets. Teal grub at shallower depths and Shoveler *Anas clypeata* less frequently, which may account for the smaller proportions of these species having lead pellets. Wigeon *Anas penelope,* Gadwall *Anas strepera* and Coot *Fulica atra,* none of which had pellets, are essentially herbivores in autumn and winter, eating leaves and stems of submergent, emergent and terrestrial plants. It is more surprising that no pellets were detected in the admittedly small samples of Tufted Duck *Aythya fuligula* and Pochard *Aythya ferina,* since Bellrose (1959) records pellets in about 13% of the North American diving ducks, Redhead *Aythya americana* and Lesser Scaup *Aythya affinis.* The situation at the Ouse Washes may be genuinely different. Snipe *Gallinago gallinago* and Moorhen *Gallinula chloropus* take their food item by item, and probably deliberately ingested the lead pellets as food or grit.

Owen and Cadbury (1975) describe the incidence of ingested lead pellets in swans found dead at the Ouse Washes. Figure 1a shows a radiograph of a Bewick's Swan *Cygnus columbianus bewickii* with four lead pellets in the gizzard, and Figure 1b exhibits these after extraction from the dissected gut.

Incidence of pellets in male and female ducks

Jordan and Bellrose (1951) have shown experimentally that the mortality rate of female Mallard due to lead poisoning is greater than that of the male except in spring when the female eats more than the male. From the Ouse Washes, there is no significant difference between the proportion of males and females containing lead pellets in the case of Mallard, Shoveler and Teal. However, of 42 male Pintail examined, 8 (19%) contained pellets, whereas only 1 (2%) of 47 females did (Fisher's Exact Probability Test, $p = 0{\cdot}00002$). Perhaps this is because, being larger and needing more food, the males come into contact with pellets more frequently whilst feeding. Males may also be feeding more deeply in the substrate because their bills, from tip to the angle, are about 6 mm longer than the females.

Weight losses

Olney (1960) states that at death the body weight of a duck suffering from lead poisoning may average only 40% of its original weight. Table 2 gives details of four Pintail shot in January 1972 which were suffering from lead poisoning. Their change in body weight is

Table 2. Weights of male Pintail suffering from lead poisoning and shot in January 1972.

Number and state of pellets in gizzard	Body weight in gm	% of 'normal weight' of 987 gm
5: partially digested	836	84·7
7: well digested	740	75·0
4: well digested	700	70·9
0: gizzard very small with bright green lining	520	52·7

compared with 'normal weights' of six male Pintail shot between 22nd and 29th January 1972 and containing no ingested lead, whose average weight was 987 gm (range 920–1,050 gm). The poisoned birds show increasingly lower weights the more the lead pellets were digested. The lowest weight was about half of the 'normal' and the wildfowler indicated that the bird was not in full possession of its flying powers when it was shot.

Monthly variation of incidence of ingested pellets

The data presented in Table 3 show that a higher proportion of Mallard have ingested lead shot in September than in any other month of the shooting season (χ^2 $p < 0{\cdot}05$). There may have been a build up of such birds in the resident population which would otherwise have been shot. Moreover, in July–August many of the remaining water bodies are flight ponds which have been relatively well shot over in the previous season, and birds feeding on them may be exposed to a higher density of lead pellets in the substrate. The populations of other species of duck are usually low in the autumn and, with the possible exception of Teal, do not then show a high incidence of lead pellets.

The nine Pintail containing lead pellets were shot in the Januarys of the study period when their population on the Ouse Washes is greatly swelled by immigrating birds taking advantage of recent flood waters. They may have ingested the lead pellets at a prior feeding locality.

Number and state of pellets in the gizzards

Table 4 details the numbers of pellets in the gizzards. Teal and Shoveler have a lower average number per gizzard than do Mallard and Pintail. This may further reflect the feeding habits of these birds. Of the duck gizzards containing lead pellets, 63% contained one pellet and 15% contained two. These figures agree closely with those for the North American ducks, 65% and 15% respectively (Bellrose, 1964). The maximum number of pellets recorded was 10 and 11, both in Mallard. The largest number ever found in a duck was 179 in a Pintail by Bellrose (1964). He also records 471 pellets in a Trumpeter Swan *Cygnus cygnus buccinator*. Waders can also ingest large numbers of pellets as was evidenced by an Avocet *Recurvirostra avosetta* which contained 55 pellets (Anon, 1972).

Birds suffering from lead poisoning tend to

Table 3. Monthly totals of gizzards examined and the number (in brackets) and % containing lead pellets.

Species	Sept.	Oct.	Nov.	Dec.	Jan.
Mallard	92(14)	56(4)	73(4)	75(7)	84(5)
	15%	7%	6%	9%	6%
Pintail	5(0)	13(0)	5(0)	15(0)	51(9)
	0%	0%	0%	0%	18%
Shoveler	32(0)	19(1)	19(1)	11(0)	21(0)
	0%	5%	5%	0%	0%
Teal	34(3)	32(1)	54	51(1)	107(4)
	9%	3%	0%	0%	4%

Table 4. Number of lead pellets in the gizzards of waterfowl from the Ouse Washes.

Number of gizzards	Number of pellets 1	2	3	4	5	6	7	8	9	10	11	Average
Mallard	21	5	2		3	1				1	1	2·3
Pintail	4	1		1	1	1	1					3·1
Shoveler	1	1										1·5
Teal	8	1										1·1
Moorhen	1					1						3·5
Snipe	1											1·0

secrete an abnormal amount of bright green bile into the duodenum and this may be regurgitated into the gizzard and proventriculus (Olney, 1960), often staining the walls. Table 5 shows the colour of the gizzard walls in the presence and absence of lead pellets. The more 'normal' colours were grey, brown, yellow or black. In all the 37 cases where pellets showed obvious signs of being digested the gizzard walls were green. There were 20 cases of apparently undigested pellets in gizzards, and in 11 of these the walls were green. Pellets described as being undigested were not shiny and in some cases were pitted and scarred; but in fact some digestion may have occurred. These is clearly an association between the presence of pellets and green walls in gizzards, especially where the pellet has obviously been digested. The birds which had green walled gizzards but no lead pellets may therefore have previously ingested pellets and digested or voided them. Such birds may or may not be in a process of recovery from lead poisoning. Bellrose (1964) points out that 10% of male and 13% of female Mallard dying from lead poisoning had no pellets in their gizzards. Jordan (Bellrose, 1959) also found that of 119 captive Mallard dosed with a single No. 6 pellet (British No. 5), 21% had no pellet in their gizzard at the time of death. This being so, the percentage of the birds shot at the Ouse Washes suffering from lead poisoning could be increased from the minimum values in Table 1 to the maximum values in Table 6 (column A) which includes birds with green gizzard walls, but no pellets.

Mortality from lead poisoning

In field experiments Bellrose (1959) has shown that Mallard dosed with 1 No. 6 pellet and released were 1·5 times as vulnerable to shooting as were the undosed controls; those dosed with 2 pellets 1·9 times, and those dosed with 4 pellets 2·1 times as vulnerable to being shot. If we assume the same vulnerabilities for Mallard at the Ouse Washes, and less confidently for other species, then we can estimate the minimum and maximum percentage of birds in the population as a whole suffering from lead poisoning (Table 6, column B). For the purposes of the calculations, birds with more than two pellets in the gizzard are all corrected by the factor of 2·1. Birds with green

Table 5. State of lead pellets and colour of gizzard walls.

	Mallard		Pintail		Teal		Shoveler		Moorhen		Snipe	
Wall colour	Green	Other	G	O	G	O	G	O	G	O	G	O
State of pellets												
Undigested	11	1				7		1				
$<\frac{1}{2}$ digested	15		6		2				2		1	
$>\frac{1}{2}$ digested	7		3				1					
None seen	16	330	6	74	7	262	4	96		30	1	65

Table 6. Lead poisoning and mortality percentages.

	A		B		C	
	% of shot birds suffering from lead poisoning		% of birds in the population suffering from lead poisoning		% mortality rate	
Species	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum
Mallard	9·0	13·2	5·2	8·0	4·0	5·9
Pintail	10·1	16·8	5·7	10·2	5·1	8·3
Shoveler	2·0	5·9	1·2	3·8	1·0	2·8
Teal	3·2	5·7	2·1	3·8	1·5	2·8
Snipe	1·5	3·0	1·0	2·0	0·7	1·4
Moorhen	6·3		4·2		3·4	

Table 7. Estimated number of deaths of waterfowl from lead poisoning on the Ouse Washes.

Species	Average of peak numbers for autumn/winters 1968–69 to 1972–73	Estimated annual number of deaths from lead poisoning	
		Minimum	Maximum
Mallard	5,000	200	295
Pintail	2,700	138	224
Shoveler	900	9	25
Teal	3,800	57	106
Snipe	1,700	12	24
Moorhen	380	13	
	Totals	429	687

gizzard walls only are treated as if they had contained one lead pellet and corrected by the factor of 1·5.

Bellrose (1959) considers that 60–80% of Mallard die if they ingest one pellet. Assuming a 70% mortality for birds with one ingested pellet or with green gizzards only, and a 90% mortality for those which ingest two or more pellets, we obtain (Table 6C) the minimum and maximum annual mortality in the population from lead poisoning. Pintail and Mallard have the highest mortalities, Shoveler and Teal being lower. Bellrose (1959) estimates that 4% of the wild Mallard in the Mississippi flyway in North America die directly as a result of lead poisoning, with another 1% affected by poisoning also being shot.

Discussion

The likelihood of waterfowl ingesting lead pellets, and the resulting mortality, depends on many factors. It varies with the species, their feeding habits and the amount of food consumed (Olney, 1960). Growing juveniles need more fod than adults and for most of the year males more than females. The more food is consumed the more likely is a bird to come into contact with lead pellets. The type of food may be important too. Mallard feeding largely on corn seem more vulnerable to lead poisoning, possibly due to a nutritive deficiency, than are birds feeding on a diet of natural seeds (Jordan & Bellrose, 1950). From late

July to October the diet of the Mallard and Teal at the Ouse Washes consists largely of stubble barley and wheat grains.

The peak numbers of each species recorded in the autumn/winter periods each year are given in Table 7. This also attempts to give the minimum and maximum numbers dying on average from lead poisoning each year. However, in some years of high populations more birds could die from lead poisoning. In 1970–1971, with a peak Mallard population of 7,430, mortality could have been as high as 440 birds. In 1973–1974 when the peak Pintail population was 3,630 the mortality could have been 300 birds. The overall average annual mortality due to lead poisoning is at least in the order of 400–700 birds. No shot birds were examined after the end of the shooting season in January when it is known that wildfowl move out from the Ouse Washes refuges and feed more extensively in the shooting areas. The percentage of the population suffering from lead poisoning may increase in this period.

The annual die off of birds suffering from lead poisoning is largely unobserved at the Ouse Washes. Wildfowl corpses, particularly ducks, are soon eaten by Carrion Crows *Corvus corone,* the larger gulls *Larus* spp and Brown Rats *Rattus norvegicus.* Sick birds may also seek cover before dying. However, Owen & Cadbury (1975) consider that most of the dead swans were recorded.

In addition to the ingested lead pellets, a lead fishing weight was found in a Mallard. Such weights are apparently ingested more frequently by swans (Owen & Cadbury, 1975). Swans, especially the Mute Swan *Cygnus olor,* frequently feed on emergent and submergent vegetation along the rivers, where angling is common and there is more chance of tackle being lost. Other metallic objects recorded as single occurrences in gizzards were: a piece of copper wire, and a fragment of steel in Mallard, a piece of steel in a Pintail, and a fishing hook in a Coot.

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Summary

The incidence of ingested lead pellets in the gizzards of waterfowl shot on the Ouse Washes, England, mainly dabbling ducks, was determined by examining 1,250 gizzards. The highest incidence was in Pintail *Anas acuta* (10%) and Mallard *Anas platyrhynchos* (9%), with lower values in Teal *Anas crecca* (3%) and Shoveler *Anas clypeata* (2%). In the case of Teal and Pintail, ingested shot was recorded for the first time in Britain. No pellets were found in Wigeon *Anas penelope* or in the small samples of Gadwall *Anas strepera,* Tufted Duck *Aythya fuligula,* Pochard *Aythya ferina* and Coot *Fulica atra.* Snipe *Gallinago gallinago* and Moorhen *Gallinula chloropus* also ingest lead pellets. In the dabbling ducks, incidence of pellets is probably related to their feeding habits; high if they commonly grub into the substrate and low if they feed mainly on leaf and stem material. Calculations, taking account of the bias that birds suffering from lead poisoning are more easily shot, indicate that the mortality of birds due to lead poisoning at the Ouse Washes is highest in Pintail and Mallard; respectively, at least 5% and 4% of their populations. In the case of the Mallard this is equivalent to the mortality reported in North America. It is estimated that the average annual mortality at the Ouse Washes due to lead poisoning is at least in the order of 400–700 birds.

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