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Authors' address:
State Veterinary Serum Laboratory,
Bülowsvej 27,
DK 1870 København V
Denmark

Introduction

Lead poisoning among waterfowl after ingestion of lead shot pellets is well documented. BELROSE (1959) gives a very detailed description of lead poisoning among waterfowl in the U.S.A., and the present situation is summarized in the report: »Proposed use of steel shot for hunting waterfowl in the United States« (ANON. 1974).

In Denmark the first case of lead poisoning in waterfowl was found in a Mallard *(Anas platyrhynchos)* in 1967 (MUNCH 1968). A Danish report (SKYDSGAARD 1974) dealing with lead poisoning in ducks after ingestion of lead shot pellets concludes: »Lead pellets as pollutants in the field should be regarded as a serious environmental and eco-toxicological factor. Apart from causing fatal lead poisoning, the ingested lead pellets can contribute to a weakness of the health status of the ducks in general«.

Concentrations of lead in the liver have been considered to be the most useful measurement for diagnosis of acute lead intoxication. Because of the kidney's essential role in excretion of body waste and ingested toxic material, lead in kidney tissues may serve as an important indicator for lead poisoning, while the lead in bone tissue has long been associated with cronic exposure. High levels of lead in muscles of lead-poisoned individuals do not seem to occur. In the Mallard levels of 6–20 ppm lead in liver and kidney indicate acute exposure (LONGCORE et al. 1974).

Discussions of lead poisoning caused the following questions to be addressed to the Minister of Environment in the Danish Parliament (Question No. 45 from the Environment Committee, September, 1976)

1. How much lead is used annually for hunting purposes?
2. How are the ecological consequences evaluated?
3. Will it be possible to use other material than lead for manufacturing pellets for hunting?
4. If it is possible, will we then have legal authority for doing so?

This paper contributes to the second point by presenting the current knowledge of lead poisoning in Danish game species, especially Mallard and Mute Swan *(Cygnus olor)*. For comparison the presence of lead pellets in gizzards from bagged Mallard is examined. Lead poisoning in other species is recorded as is the amount of lead in the tissue. The lead poisoning in waterfowl in connection with public health is also considered.

Material and Methods

From all over the country wild mammals and birds found dead or ill are forwarded to the State Veterinary Serum Laboratory for autopsy. As the animals are often sent deep frozen, or in various stages of decay, no histological examination was carried out in this survey. This material comprises the majority, but the survey has been supplemented with specimens of apparently normal game shot for control, and during ordinary hunting.

The material was received during the years 1971–1977 (Tables 2, 8, and 16). Lead-poisoned birds recorded during the period 1967–1970 are also included in the survey, while individuals estimated to be less than four months old were omitted from the material.

When the Mallard were reported as having been raised in an artificial pond or given food supplies they were recorded as »reared« in the material. Wing-clipped birds were also recorded as raised. The Mallard were recorded as free-ranging, when they were found by chance in the field.

During the period October 1st – December 19th 1975 3,149 gizzards were collected from Mallard sent for sale to game dealers in Copenhagen (2,817) and Århus (332). The gizzards were collected twice a week. At the laboratory they were cut up and the contents washed into a sieve. When pellets were found, they were evaluated following the guide lines given by BELROSE (1959) as to whether they were ingested or shot into the gizzard. Eroded pellets were regarded as ingested, while pellets with craters caused by striking others in passage along the gunbarrel were recorded as shot into the bird. This assumption could usually be verified by the discovery of shot-holes in the gizzard. In cases where the Mallard were killed just after ingestion of a pellet which recently left a gunbarrel misinterpretation may occur, but in the present survey this error is thought to be of no significance.

Species	No.
Hare *(Lepus capensis)*	26
Fox *(Vulpes vulpes)*	17
Badger *(Meles meles)*	1
Stone Marten *(Martes foina)*	22
Buzzard *(Buteo buteo)*	30
Sparrow Hawk *(Accipiter nisus)*	7
Peregrine Falcon *(Falco peregrinus)*	1
Kestrel *(Falco tinnunculus)*	10
Osprey *(Pandion haliaetus)*	1
Tawny Owl *(Strix aluco)*	6
Longeared Owl *(Asio otus)*	2
Little Owl *(Athene noctua)*	1

Table 1. Numbers of Hare, Mammalian Carnivores, Birds of Prey and Owls analysed. The material was received during 1976 and 1977.

Besides the Mute Swan sent for autopsy, the material also included some healthy specimens shot near airports and some especially shot for examination of lead poisoning.

Mute Swan with brown plumage were recorded as less than one year old, while birds with white plumage were recorded as more than one year old.

Analyses were also made using liver and kidney of various game species received during 1976 and 1977 (Table 1). The 20 Brown Hare *(Lepus capensis)* were apparently normal individuals shot during the hunting season, while the other 6 had died from various diseases. Of the Fox *(Vulpes vulpes)* 15 were shot, and 2 had died from disease. The single Badger *(Meles meles)* was shot, and 6 of the Stone Marten *(Martes foina)* were shot, the other 16 being trapped or killed by traffic. All birds of prey and owls were found dead (injury, infections, parasitic diseases or shot).

In the present survey mainly the liver but also the kidney and sometimes the muscle tissue were used for analyses. After autopsy the tissues were stored in plastic bags at –20°C until the analyses were begun. The following three techniques were used for analysis.

ANALYTICAL METHOD 1:

After wet digestion of the tissue, the lead was extracted by dithizone in chloroform followed by polarographic determination of the lead concentration (KARLOG & MØLLER 1958).

ANALYTICAL METHOD 2:

A known amount of homogenized tissue (ca. 2 g) was wet digested and dissolved in 2 N HCl (final volume 10 ml). The concentration of lead in the solution was determined by atomic absorption spectrophotometry (Perkin-Elmer, model 403) according to the manufacturer's specification (ANON. 1971). Standard solutions of lead were treated like samples.

The recovery of the method was examined as follows: To samples containing 2 μg Pb/g 5 or

10 μg Pb were added and to samples containing 100 μg Pb/g 20, 50, 80 og 100 μg Pb were added. The mean recovery percentage was 100 ±7.2 (RSD) (n=15).

The accuracy of the method was also checked by the standard addition method. Samples containing 19–25 or 32 μg Pb/g were used giving results within the standard deviation for the recovery method.

ANALYTICAL METHOD 3:

5–10 g homogenized tissue was dry ashed and dissolved in ca. 1 N HCl. After extraction with diethylammonium-diethyldithiocarbamate/xylene, the concentration of lead in the organic phase was determined by atomic absorption spectrophotometry (ROSCHNIK 1973).

Recovery tests were made adding 1–2 or 3 μg Pb to 10 g samples containing 0.33 or 0.62 μg Pb/g. The mean recovery percentage was 99 ±5.5 (RSD) (n=5).

Methods 2 and 3 were compared by analyses of samples from 8 lead-poisoned animals (9–27 μg Pb/g liver and kidney). Except for two Mute Swan with a very high copper concentration in the liver, the differences between the two methods were within the standard deviation for the methods.

In method 3 there seemed to be an interference from copper content when levels exceeded 1500 μg Cu/sample during extraction. For that reason the copper concentration was measured in all Swan livers which were planned to be analysed by this method, and the amount of liver in the aliquot was limited to eliminate copper interference.

The copper content of kidneys from the Mute Swan and in liver and kidney from the other species was so low that any interference from copper was out of question.

Organs from birds examined before April 1st 1973 were analysed by method 1 at the Department for Pharmacology and Toxicology of the Royal Veterinary and Agricultural University Copenhagen, while organs from birds received after this date were analysed by method 2 in cases where the purpose was to determine whether the bird was lead-poisoned or not.

Method 3 was used when the purpose was to find the exact amount of lead in the mammals and birds examined.

Birds were evaluated as lead-poisoned when the concentration of lead in the liver or kidney exceeded 15 ppm, or the concentration was from 7–14 ppm and signs of lead poisoning were found at autopsy.

After 1971 lead poisoning in Mallard was sometimes only diagnosed after autopsy. The criteria had been lack of other cause of death, lead pellets in the gizzard and presence of some of the post mortem changes which are characteristic of lead poisoning, i.e. pale lungs and muscles, impaction at the proventriculus and distended gall bladder.

A few Mute Swan (9 birds) were recorded as lead-poisoned without analyses after having been found with large numbers of pellets in the gizzard, and signs of lead poisoning at autopsy.

Results

MALLARD

Lead poisoning

The Mallard is the species of waterfowl most frequently affected by lead poisoning in the U.S.A. (BELROSE 1959). In Denmark the Mallard is the most common breeding duck species, but it is also numerous during migration and in winter-time. In the period 1971–1976 an average of 366,000 individuals were shot annually (STRANDGAARD 1973–77). The

Year	1971	1972	1973	1974	1975	1976	1977	Total No.	Total %
Free-living, total	8	49	19	12	15	16	20	139	
Free-living, lead-poisoned	0	0	1	1	3	1	1	7	5
Raised, total	15	30	30	26	43	44	21	209	
Raised, lead-poisoned	2	2	8	11	21	8	11	63	30
Mallard, total	23	79	49	38	58	60	41	348	
Lead-poisoned, total	2	2	9	12	24	9	12	70	20
Lead-poisoned, %	9	3	18	32	41	15	29	20	

Table 2. Numbers of Mallard more than 4 months old sent for autopsy during 1971–77.

	No.	%
Total	81	
Raised birds	73	
Free-ranging birds	8	
♂	23	
♀	51	
Sex not recorded	7	
Nutrition: normal	53	
Nutrition: below normal	10	
Nutrition: emaciated	18	
Autopsy results:		
No special signs	11	14
Pale muscles and lungs	49	60
Impaction of oesophagus	2	2
Impaction of proventriculus	18	22
Enteritis	5	6
Green diarrhoea	7	9
Distended gall bladder	19	23

Table 3. Examination of Mallard recorded as lead-poisoned during 1967–1977.

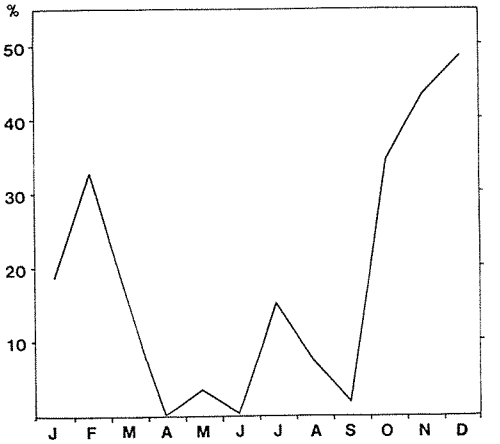

Fig. 1. Lead-poisoned Mallard as a percentage of the total number of Mallard more than 4 months old examined each month from January 1st 1967 to December 31st 1977.

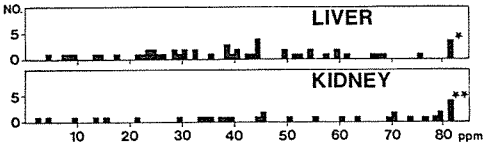

Fig. 2. The distribution of lead levels in 52 livers and 33 kidneys from lead-poisoned Mallard. The average lead level in liver was 40.5 ppm and in kidney 58.1 ppm.
*) 89, 91 and 109 ppm.
**) 89, 108, 136, 147 and 170 ppm.

bag included a lot of Mallard raised with different degrees of human support in natural and artificial small ponds, with food supplies etc., and therefore the bag varied from completely wild birds to permanently wing-clipped individuals from enclosed areas.

During 1967–1977 the total number of lead-poisoned Mallard received for autopsy was 81. Of these 20 were from Zealand and surrounding islands, 22 from Funen and surrounding islands, and 39 from Jutland. The authors found 70 lead-poisoned individuals during 1971–1977 (Table 2) while the remaining 11 were recorded in previous years. The distribution during the year is shown in Fig. 1, and Table 3 contains information from autopsies. The distribution of lead in liver and kidney from lead-poisoned Mallard is shown in Fig. 2, while Table 4 shows the distribution of pellets in gizzards of lead-poisoned Mallard, compared with American results.

No. of pellets in the gizzard	Denmark		U.S.A.	
	No.	%	No.	%
0	13	20	132	11
1	8	12	284	25
2	4	6	195	17
3	2	3	155	13
4	3	5	98	8
5	2	3	78	7
6	1	1	53	5
7	3	5	27	2
8	3	5	25	2
9	1	1	20	2
10	1	1	18	2
> 10	25	38	68	6
Total	66	100	1153	100
Source	Present study		Belrose(1959)	

Table 4. Comparison of the distribution of the number of pellets in the gizzards of lead-poisoned Mallard in the present study and an American study. (In the Danish material the pellets in 15 gizzards were not counted).

Lead pellets in the gizzard of bagged Mallard

The frequency with which apparently normal Mallard contain ingested pellets gives an impression of the dimension of the lead-poisoning problem, and in accordance with this, examination of gizzards from Mallard shot during the open season has been carried out in several countries (Table 5).

Country	Period	Number of gizzards examined	Percentage with ingested pellets	Source
U.S.A.				
Atlantic Flyway	1938–1953	223	6.3	
Mississippi Flyway	1938–1953	10801	8.4	Belrose (1959)
Central Flyway	1938–1953	3918	2.7	
Pacific Flyway	1938–1953	3265	8.2	
England	1957–1959	244	6.6	Olney (1960)
	1968–1973	380	9.0	Thomas (1976)
Sweden	1972–1974	272	10.3	Danell & Andersen (1975)
Denmark	1974	52	17.3	Wium-Andersen & Franzmann (1974)
	1975	3149	2.4	Present study

Table 5. Incidence of pellets in the gizzard of bagged Mallard.

Period	Gizzards examined	Gizzards with ingested lead pellets		Ingested lead pellets	Average of ingested pellets per Mallard	Mallard with pellets shot into the gizzard	
	No.	No.	%	No.	No.	No.	%
October	1245	26	2.1	68	2.6	61	4.9
November	1012	19	1.9	111	5.8	45	4.4
December	892	32	3.6	77	2.4	25	2.8
Total	3149	77	2.4	256	3.3	131	4.2

Table 6. Gizzards examined for lead pellets from Mallard bagged during the period October 1st – December 31st 1975. In two cases a nickel pellet and an iron pellet were found.

Pellets ingested No.	Denmark No.	Denmark %	U.S.A. %
1	38	49	65
2	13	17	17
3	14	18	7
4	4	5	3
5	0	0	2
6	1	1	1
7	1		
8	1		
9	0		
10	0		
11	1	9	6
13	1		
15	1		
16	1		
58	1		
Source	Present study		BELROSE (1959)

Table 7. Distribution of ingested pellets in gizzards of 77 Mallard bagged in Denmark and 1,159 bagged in U.S.A.

The present survey was carried out in order to determine the prevalence of ingested pellets in apparently healthy Mallard shot in Denmark during the open season in 1975.

Pellets found in the gizzards from 77 Mallard were evaluated as ingested, corresponding to 2.4% of the total number of gizzards examined (Table 6). Table 7 shows the distribution of the 256 ingested pellets found in the 77 gizzards, the result being compared with American findings.

MUTE SWAN

Lead poisoning

Swans are often exposed to lead poisoning after ingestion of lead pellets (TRAINER & HUNT 1965; IRWIN 1975; MUNRO 1925), but lead poisoning from other causes than lead pellets may also occur (BENSON et al. 1976).

In 1966 the breeding population of the Mute Swan in Denmark was 3,000 pairs (BLOCH 1971), furthermore some 40–70,000 specimens winter in large flocks in Danish waters (JOENSEN 1974). Lead poisoning has been recorded among Mute Swan in Denmark, and was found to

Year	1971	1972	1973	1974	1975	1976	1977	Total No.	Total %
Total	2	10	22	2	38	146	78	298	
♂	1	2	14	1	23	71	38	150	
♀	1	6	8	1	11	64	35	126	
Sex not recorded	0	2	0	0	4	11	5	22	
>1 year old	2	7	5	1	28	94	46	183	
<1 year old	0	3	17	1	10	52	32	115	
Cause of death:									
Lead poisoning	0	1	0	1	9	60	7	78	26
Killed by shooting								58	19
Injury								47	16
Infection								28	9
Starvation								43	14
Other causes								44	15

Table 8. Autopsy results of 298 Mute Swan. (Of the 58 individuals killed by shooting, 28 were shot with special permission).

Concentration of lead in the liver	0–6 ppm	7–14 ppm	15–103 ppm
Total number	50*)	12**)	57
♂	26	7	32
♀	24	5	25
>1 year old	37	8	49
<1 year old	13	4	8
Nutrition: normal	23	2	7
Nutrition: below normal	8	1	12
Nutrition: emaciated	19	9	38
Autopsy:			
Killed by shooting	12	1	1
Injury	13	0	0
Infection	9	1	2
Parasitism	2	1	2
Starvation	6	0	0
Unknown cause of death	8	3	6
Recorded as lead-poisoned	0	6	46
Post mortem signs of lead poisoning:			
Pale muscles and lungs	0	1	10
Impaction of oesophagus	0	1	15
Impaction of proventriculus	0	5	23
Enteritis	2	4	22
Green diarrhoea	1	2	12
Distended gall bladder	6	5	33
Lead pellets in the gizzard	0	3	33

Table 9. Autopsy results and lead analyses of 119 Mute Swan.
*) Of three livers with more than 3 ppm two had kidney values from 7–14 ppm and one over 15 ppm.
**) Kidneys from six of these Swan were also analysed, all exceeding 15 ppm.

Country	Canada		U.S.A.		Denmark	
Source	Irwin (1975)		Trainer & Hunt (1965)		Present study	
	No.	%	No.	%	No.	%
Emaciated	15	71	No record		60	87
Impaction of proventriculus	7	33	11	29	28	41
Enteritis	No record		21	54	26	38
Green diarrhoea	11	52	21	54	14	20
Distended gall bladder	8	50	37	94	38	55
Lead pellets in the gizzard	18	90	37	94	36	52

Table 10. Prevalence of gross lesions in lead-poisoned Whistling Swan in Canada and U.S.A., compared to lesions in Mute Swan from Denmark.

cause a high local mortality (CLAUSEN et al. 1975).

The results of autopsies of 298 birds are given in Table 8, while Table 9 and Fig. 3 give more detailed information on autopsies of 119 specimens examined and analysed for lead in liver and kidney. In Table 10 the most frequent post mortem findings are compared with results from the U.S.A. and Canada.

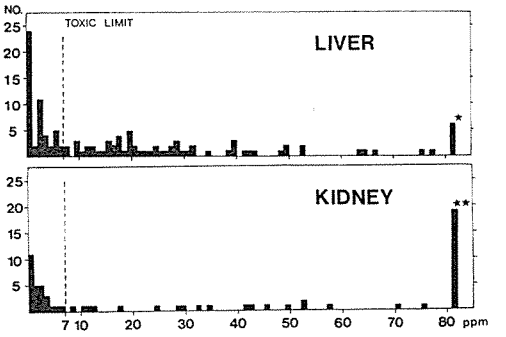

Fig. 3. The distribution of lead levels in 119 livers and 65 kidneys from Mute Swan examined. The avarage lead level in liver and kidney was 32.9 and 104.8 ppm respectively. Of the 119 livers, 69 contained more than 7 ppm, which is the toxic limit. Of the 65 kidneys, 38 contained more than 7ppm.
*) 81, 84, 86, 88, 100 and 103 ppm.
**) 89, 97, 103, 108, 110, 123, 124, 135, 147, 156, 164, 185, 192, 215, 230, 239, 240 and 410 ppm.

Lead poisoning near clay-pigeon shooting sites

While lead poisoned Mallard are found singly or in small numbers, it is characteristic for lead-poisoned Mute Swan to be found in large numbers at a few localities (Tables 11 and 12).

Place	Period	Estimated No. of dead birds	No. examined	Gizzards with lead pellets		Lead in liver ppm			Trap shooting
				No.	%	0–6	7–14	≧15	
Rødsø	Feb.–Mar. 1975	20	7	7	100	0	0	7	+
Ølsemagle Reef	Feb.–Mar. 1976	150–200	37	13	35	2	7	27	+
						(only 36 analysed)			
Helnæs	October 1976	30	10	10	100	(only 4 analysed)		4	+
Rødby	March 1976	60–70	15	8	53	2	3	10	+
Rødby	Dec.–Mar. 1976–1977	30–40	5	5	100	not analysed			+
Ringkøbing Fjord	1974–1977	?	14	10	72	(only 8 analysed)		8	

Table 11. Outbreak of lead poisoning among Mute Swan.

Localities

Rødsø

Rødsø is a lake in Jutland where at least 20 out of 100 Mute Swan died in February–March 1975. Duck hunting occurs every autumn and a trap shooting site is placed on the shore. The area where the lead pellets fall is partly flooded during winter time. This outbreak has previously been described (CLAUSEN et al. 1975).

Ølsemagle Reef

In February 1976 large numbers of Mute Swan were reported dead or very weak at Ølsemagle Reef, Zealand. Each year hundreds of Swan winter in this area, either at sea outside the reef or in the lagoons behind the reef. Waterfowl are hunted intensively, and two trap-shooting sites are situated in the area.

Area	Soil samples No.	Distance from shooting site m	Sample size cm^2	Average of pellets/ m^3 No.	Remarks	Source
Ølsemagle, Zeeland	2	50	100 & 150	2,150		Present study
Rødby, Lolland	18	50–100	177	44		JENSEN (1977)
Helnæs, Funen	25	110–220	100 & 200	506		HOLM (1977)
Ringkøbing Fjord, Jutland	14	85–125	70 & 100	155	The samples were taken in a protected area.	MØLLER(1973)
Ringkøbing Fjord, Jutland	240 from 6 areas		79–177	10.1-183.4	Average from 6 inlet lagoons known as resting places for migrating waterfowl.	PETERSEN (1978)
U.S.A.				29.1	The samples derive from 22 areas and were taken 1939–56.	BELROSE(1959)
U.S.A.	200			2.7–10.8	One percent of the Mourning Dove from the area had pellets in the gizzard.	LEWIS & LEGLER (1968)
U.S.A.	22	30–360	5,000	0.9–4.0	An estimate of 5 % of the resting Canada Goose died of lead poisoning.	SZYMCZAK & ADRIAN (1978)
Mexico	162			9.9		SCHRANCK & DOLLAHON (1975)
New Zealand				2.3–5	Lead-poisoned birds found in the area.	CAITHNESS (1974)

Table 12. Pellets found in areas where outbreaks of lead poisoning among Danish Mute Swan are recorded, compared to soil samples from shooting areas in the U.S.A., Mexico, and New Zealand.

Helnæs

In the beginning of October 1976 about 150 apparently healthy Mute Swan were seen at sea along the east coast of the peninsula of Helnæs, Funen, and about 30 of these were found dead on the beach a few weeks later. A large clay pigeon shooting site is situated near the sea.

According to local trap-shooters about 6,000 kg of lead pellets are annually shot over the water, the depth of the water within the shooting range being about one metre.

Eight swans were examined by the authors and two by a local Game Adviser. In the gizzards 61, 100, 253, 280, 285, 412, 459, 906, 961 and 3,355 (96 g) pellets were found respectively. Organs from four of these birds were analysed and 48–75 ppm of lead were found in livers and 108–156 ppm in kidneys. The bird with 3,355 pellets in the gizzard contained 63, 147, and 1.5 ppm of lead in the liver, kidney and muscle tissue respectively.

After November 1st no more dead Swan were found. In order to see whether the surviving birds carried lead in their organs, ten apparently normal birds were shot within the area two weeks later (Table 13).

Rødby

In a little lake near Rødby, Lolland, 60–70 Mute Swan died in March 1976. Eight out of 15 birds examined had lead pellets in the gizzard, numbering from 1 to 486. A trap-shooting site was situated near the little lake and most of the pellets fell into the water, the depth being about 1 m. During the winter of 1976–77 30–40 Mute Swan died in the same lake; of these 4–5 were

Sex	Age	Nutritional state	Weight kg	Lead Liver ppm	Lead Kidney ppm	Pellets in gizzard
♂	>1 year old	Good	12	ND	1.3	0
♂	<1 year old	Below normal	6	0.8	2.9	0
♂	>1 year old	Good	15	0.2	0.4	0
♂	–	Emaciated	9	0.1	0.2	0
♀	–	Emaciated	6	14	43	4*)
♀	–	Below normal	7	ND	0.8	1
♂	–	Good	11	0.4	0.5	0
♂	–	Good	12	ND	0.8	0
♀	–	Good	11	0.4	0.4	0
♀	–	Below normal	10	0.1	0.1	0

Table 13. Autopsies and analyses of 10 Mute Swan shot in November 1976 two weeks after the end of an outbreak of lead poisoning near Helnæs.
ND: Not determined. *) No sign of lead poisoning seen at autopsy.

more than one year old and the rest less than one year.

The birds were too decomposed for autopsy but in five gizzards 96, 101, 113, 118, and 158 lead pellets were found respectively (F. JENSEN, pers. comm.). Most of the pellets were 2.5 mm in diameter, while the rest were 2 mm. (The same size of pellets is normally used for clay-pigeon shooting).

Ringkøbing Fjord

Ringkøbing Fjord, Jutland, has shallow brackish water and salt marshes. Very large numbers of migrating waterfowl shelter in the area each spring and autumn. Some areas are protected, while very extensive shooting takes place in others. Every year several Mute Swan are found dead in the area and autopsy reveals that they are usually lead-poisoned or shot.

Lead poisoning in Mallard and Mute Swan

During autopsy and chemical analyses of lead-poisoned Mallard and Mute Swan some characteristic conditions were recorded (Tables 14 and 15).

Lead poisoning in other bird species

Up to 1971 lead poisoning in other bird species in Denmark has only been recorded in a Pheasant *(Phasianus colchicus)*, a Tufted Duck *(Aythya fuligula)* and a Pochard *(Aythya ferina)*. In the years 1971–1977 a few more have been recorded as lead-poisoned (Table 16) and the cases are described below;

1. In January 1971 a Goldeneye *(Bucephala clangula)* was found dead in Ringkøbing Fjord, Jutland. The bird, an adult male, was emaciated, and in the gizzard 10 pellets were found. The liver and kidney contained 23 and 14 ppm of lead respectively.
2. In May 1973 a Goldeneye was found sick in Nissum Fjord, Jutland. The bird, an adult female, was in a normal state of nutrition. In the oesophagus a few pellets were found; the gizzard was empty. The liver contained 53 ppm of lead.
3. In May 1974 an Eider *(Somateria mollissima)* was found dead on Christiansø northeast of Bornholm. The bird was an adult female. The muscles were pale, and the proventriculus was impacted, but no pellets were seen in the gizzard. The liver, kidney, and muscles contained 13, 100, and 0.3 ppm of lead respectively.
4. In June 1976 a Partridge *(Perdix perdix)* was found in Skørpinge, Zealand. The bird, an adult male, was extremely emaciated. No sign of lead poisoning was seen at autopsy, but the gizzard contained 34 partly new pellets.

	Mallard		Mute Swan	
	No.	%	No.	%
♂	23	31	39	57
♀	51	69	30	43
Sex not recorded	7			
Nutrition: normal	53	65	9	13
Nutrition: below normal	10	12	13	19
Nutrition: emaciated	18	22	47	68
Post mortem signs of lead poisoning:				
Lead pellets in gizzard	68	84	36	52
Pale muscles and lungs	49	60	11	16
Impaction of oesophagus	2	2	16	23
Impaction of proventriculus	18	22	28	41
Enteritis	5	6	26	38
Green diarrhoea	7	9	14	20
Distended gall bladder	19	23	38	55
Lead in liver (average)	52	40.5 ppm	69	32.9 ppm
Lead in kidney (average)	33	58.1 ppm	38	104.7 ppm

Table 14. Examination of 81 Mallard and 69 Mute Swan recorded as lead-poisoned.

	Mallard		Mute Swan	
Number of pellets	No.	Lead in liver ppm	No.	Lead in liver ppm
0	12	37	25	24
1– 9	14	35	10	36
10–19	6	47	8	52
20–99	4	46	8	39
>100	0		5	68

Table 15. Lead concentrations in livers of lead-poisoned Mallard and Mute Swan in relation to number of pellets in the gizzard.

Species	Number examined	Number lead-poisoned
Pheasant (>4 months old)	199	0
Partridge (>4 months old)	62	1
Ducks other than Mallard	77	3
Swans other than Mute Swan	5	2
Geese	55	0
Gulls	351	0
Wood Pigeon	142	1
Birds of Prey	250*)	0
Other species	414	0

Table 16. Number of birds of different species (except Mallard and Mute Swan) subjected to autopsy during 1971–1977. *) See Fig. 4.

The liver and kidney contained 130 and 440 ppm of lead respectively.

5. In April 1976 a Wood Pigeon *(Columba palumbus)* was found dead at Brande, Jutland. The bird was an adult female, and the nutritional state was below normal. Food was packed in the crop, and eight pellets were seen in the gizzard. The bird had suffered from diarrhoea. The liver, kidney, and muscles contained 48, 200, and 1.3 ppm of lead respectively.
6. In April 1976 a Whooper Swan *(Cygnus cygnus)* was found dead in Ringkøbing Fjord, Jutland. The bird was a young female and the nutritional state was below normal. The oesophagus was packed with food, and the liver contained 61 ppm of lead.
7. In December 1976 a Whooper Swan was killed after being found very weak in Guldborgsund, south of Zealand. The bird, a young female, was emaciated. The lungs were pale and food was packed in the oesophagus and proventriculus. The liver and kidney contained 37 and 68 ppm of lead respectively.

The load of lead in some Danish game species

The load of lead in the liver as well as in the meat from Danish cattle, pigs and poultry is below 0.5 ppm, with very few exceptions (ANDERSEN & ENGBERG 1977, ENGBERG 1974).

From analyses of 226 American birds including 27 species, only a few had more than 1.5 ppm and none had more than 7 ppm of lead in the liver (BAGLEY & LOCKE 1967).

The load of lead in game from Denmark has not been known up to now. Therefore, analyses of lead concentrations in organs from various species which are not normally found to be lead-poisoned, were performed. Most of the material consisted of mammalian carnivores, birds of prey and owls in order to see whether lead is concentrated up through the food chains. (Table 1 and Fig. 4).

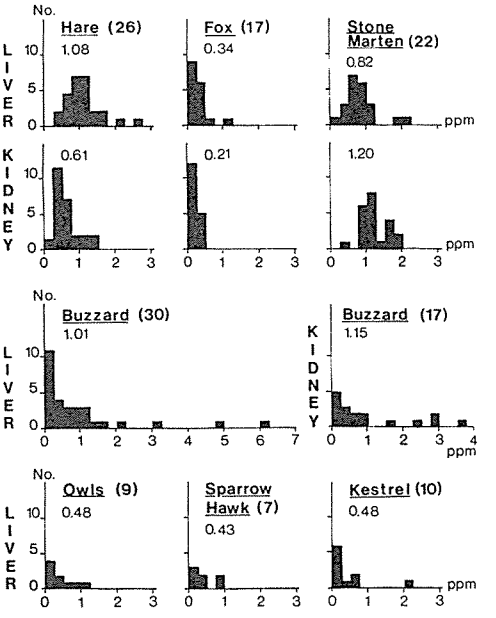

Fig. 4. The distribution of lead levels in liver and kidney of different game species. The figure in brackets indicates the number of specimens examined. The figure below the name of the species indicates the average lead level.

A Badger had 0.83 ppm in the liver and 0.43 ppm in the kidney. A Peregrine Falcon and an Osprey had 0.24 and 0.25 ppm in the liver respectively.

Lead poisoning in game birds in connection with public health

Though lead is toxic to humans, no maximum figures for acceptable concentrations of lead in food are given, but from FAO/WHO a guide line of 3 mg lead in the food is given as a provisional weekly intake (ANON. 1972).

Waterfowl are known as potential victims of lead poisoning, and concerning public health it is important to know the lead concentration in muscle tissue of such birds. Fig. 5 shows the lead in pectoral muscle from 24 Mallard and 9 Mute Swan, all found with lethal concentrations of lead in the liver.

Analyses of muscles from an Eider Duck, a Tufted Duck, and a Wood Pigeon with 13, 24, and 48 ppm of lead in the liver, respectively, showed the same low values ranging from 0.3 to 1.3 ppm in the muscles.

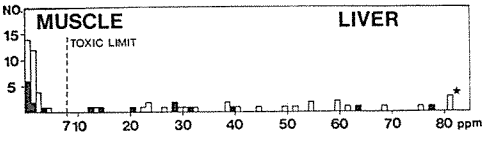

Fig. 5. The concentration of lead in muscle and liver of 24 Mallard (white columns) and 9 Mute Swan (black columns), all lead-poisoned. The average lead level in muscle from all 33 birds was 1.2 ppm at the most, as all samples containing less than 1 ppm were counted as 1.0 ppm. The average lead level in liver from the same birds was 44.9 ppm.
*) 89, 91 and 109 ppm.

Discussion

About 20 % of the Mallard subjected to autopsy during 1971–1977 were lead-poisoned and this can be regarded as one of the most common causes of death in Mallard sent for autopsy.

It has previously been stated that lead poisoning primarily occurs among raised Mallard (MUNCH 1968; CLAUSEN 1976). The present survey seems to support this statement as only 5 % of the free-living birds examined were found to be lead-poisoned, as opposed to 30 % of the raised birds (Table 2).

From the information accompanying the Mallard it can be seen that among free-ranging birds it is single specimens that are usually found dead in contrast to raised birds where several are often reported dying with the same symptoms as the bird sent for autopsy, and some ponds at present seem so heavily polluted with lead pellets that they cannot be used for raising Mallard.

Lead-poisoned Mallard are found all over the country. The number of lead-poisoned individuals increases during autumn (Fig. 1) which might be caused by the increasing number of lead pellets available in the upper layers of the lake bottom during the shooting season, but probably also because the birds search the bottom more carefully for food during winter time, when only little food is available on the surface.

It was found that the percentage of Mallard with ingested pellets was lower than recorded elsewhere (Table 5). An explanation could be a wrong evaluation of whether a pellet was ingested or shot into a gizzard. However even if no such evaluation was carried out and all birds with pellets in the gizzard were recorded as having ingested it, the value would only be 6.6 % (Table 6), i.e. approximately that which is found elsewhere (Table 5).

As already mentioned, the bag of Mallard varies from completely free-ranging birds to domesticated individuals, but in the present material it was not possible to decide from which category the gizzard originated. As a compensatory factor a relatively large number was collected, i.e. 3,149 gizzards or 0.83 % of the 380,000 Mallard shot during 1975 (STRANDGAARD 1976).

It was found (Table 6) that gizzards with ingested pellets are distributed equally over the collecting period, and apart from a single day in November such gizzards were found in small numbers in most of the samples. Even if the material is too limited for more extensive comparison, it appears that the number of ingested pellets in each of the 77 Mallard is higher than that found in Mallard from the U.S.A. (Table 7).

An average of 3.3 ingested pellets were found in the 77 gizzards from the Danish Mallard, while in a similar investigation in England, an average of 2.3 pellets were found in 33 gizzards (THOMAS 1976). These findings support the assumption that a relatively large number of pellets is available at the localities where the birds ingest lead pellets (see also Table 12).

Lead poisoning is found to be the major cause of death in Mute Swan sent for autopsy. Nearly all the birds with more than 7 ppm in liver or kidney show signs of being lead-poisoned on autopsy, while individuals with less than 7 ppm are usually found to die from other causes. The gross lesions are nearly the same in lead-poisoned Whistling Swan *(Cygnus columbianus)* in Canada and the U.S.A. as in Mute Swan from Denmark. On the other hand, the percentage of

lead pellets in the gizzard appears to be lower in Danish Mute Swan than in the American Whistling Swan (Table 10). In other areas Whistling Swan have been found lead-poisoned, not from pellets, but from mining works (BENSON et al. 1976). The lower figure from Denmark may also be caused by intoxication from other sources than shotgun pellets; in Mute Swan from Ølsemagle Reef, only 35 % had pellets in the gizzard.

A chemical works is placed close to Ølsemagle Reef and waste water from this is released into the lagoons, and the content of lead and copper both in soil and organic material is higher than that found in unpolluted areas in Denmark (VESTERGAARD 1975). Livers from the Mute Swan which died in the area were found to contain 2–3 times more copper than livers from birds found in other areas in Denmark (CLAUSEN & WOLSTRUP 1978). Waterfowl are shot intensively in the lagoons, and from two shooting sites clay pigeons are shot down over the lagoons. The number of lead pellets per square metre was very high (Table 12) and it is believed that most of the Mute Swan died of lead poisoning after ingesting lead pellets but they could very well have received some lead from waste water discharged from the works as well.

It seems that Mute Swan on occasion are able to pick up even very large numbers of pellets, the maximum of 3,355 pellets in one gizzard being much higher than any number recorded elsewhere. It is beyond any doubt that trap shooting, when carried out over shallow water, creates a hazard to waterfowl, especially Mute Swan, which may become lead-poisoned. Examination of the ten Mute Swan shot after the end of the outbreak of the lead poisoning near Helnæs (Table 13) indicates that the birds either die of lead poisoning or do not get affected at all.

The high concentration of lead pellets in soil samples from Denmark is not directly comparable to the findings from shooting areas in other countries as three out of five sampling areas are within shooting range of trap shooting sites. However, the results from Ringkøbing Fjord show that the concentration of lead pellets can be very high even in areas where only shooting takes place (Table 12).

Thousands of waterfowl use Ringkøbing Fjord as a refuge during spring and autumn. Most of the birds only stay for a short period in the area, and it is not known whether they pick up lead pellets when feeding, but it is remarkable that the concentration of 0.9–2.4 pellets/m^2 in Colorado, U.S.A., causes an estimated 5 % mortality of the Canada Goose *(Branta canadensis)* which occur in that area (SZYMZCAK & ADRIAN 1978). These concentrations of pellets are more than 50 times lower than that found in Ringkøbing Fjord. It is also found that several Mute Swan which usually spend some months in the Ringkøbing Fjord area become lead-poisoned, and the possibility that some migrating waterfowl leave the area with newly-ingested pellets in their gizzards cannot be excluded.

The typical lead-poisoned Mallard is a raised bird in a good state of nutrition; the most characteristic post-mortem findings are pellets in the gizzard, and pale muscle, and lung tissue. The typical lead-poisoned Mute Swan is a free-ranging bird, which is emaciated, and the most characteristic post-mortem findings are impaction of food in the oesophagus and proventriculus and distended gall bladder (Tables 9 and 14).

There does not apparently seem to be any direct correlation between the amount

of lead in the liver and the number of ingested pellets, and the concentration of lead in the organs from Mallard and Mute Swan which died from lead poisoning seems to be approximately the same (Table 15).

The number of lead-poisoned individuals in other species must be regarded as a minimum because lead poisoning in general is not expected during autopsy, and analysis is only performed when findings during autopsy cause lead poisoning to be suspected. The number of other duck species examined is too small for general conclusions, but even with these reservations in mind the findings do not affect the general statement, that in Denmark lead poisoning mainly occurs among Mallard and Mute Swan.

Except for the Buzzard *(Buteo buteo)* all bird species examined had the same low concentration of lead, and the content of lead in liver was about the same as that found in 226 American birds (BAGLEY & LOCKE 1967). In the Buzzard three of the 30 birds examined had concentrations of lead in the liver of 3 ppm or more. The number of Buzzard examined was too small for definite conclusions, but the possibility of the increased concentration of lead being caused by preying on lead-poisoned waterfowl or game with pellets in the tissue cannot be excluded. Similar cases are known from Sweden, where two Golden Eagle *(Aquila chrysaëtos)* were found with 36 and 10 ppm lead in the liver (BORG 1975). Mute Swan dying from other causes than lead poisoning (Table 9) have the same low concentration of lead in the liver as other species.

The concentration of lead in the Brown Hare in Denmark is about the same as that found in Swedish hares, i.e. 0.9 ppm on average in 12 Blue Hare *(Lepus timidus)*, and 1.9 ppm in 17 Brown Hare (BORG 1975).

Of the mammals examined only the Fox might eat prey with ingested lead pellets, but the concentration of lead in organs from the Fox was about the same level as those from the Hare and Stone Marten, and thus no food chain concentration of lead seems to be occurring in the Fox.

The present study appears to support previous analyses in which it was found that the concentration of lead is low in muscle tissue, even in birds with high levels in kidney, liver, and bone tissue (LONGCORE et al. 1974, SZYMCZAK & ADRIAN 1978). It may be assumed that liver and especially kidney and bones from waterfowl do not comprise a major part of the diet of most people, and therefore lead-exposed and lead-poisoned birds are not believed to be a hazard to the consumer.

Dansk resumé

Blyforgiftning i vildt fra Danmark

I denne artikel summeres den nuværende viden om forgiftning blandt svømmefugle i Danmark som følge af optagelse af blyhagl.

Undersøgelsen omfatter dødfundet vildt, der i perioden 1971–1977 er indsendt til obduktion på Statens Veterinære Serumlaboratorium. For enkelte arters vedkommende går opgørelsen tilbage til 1967, hvor det første danske tilfælde af blyforgiftning (en gråand) blev registreret.

Der skelnes i undersøgelsen mellem fritlevende og opdrættede gråænder. I perioden 1971–1977 er der i alt undersøgt 348 gråænder, hvoraf 70 (20 %) var blyforgiftede.

Af disse skønnedes 7 at være fritlevende og 63 opdrættede (Tabel 2). Antallet af blyforgiftede tilfælde stiger i løbet af efteråret (Fig. 1). Obduktionsresultaterne af de blyforgiftede gråænder, der er undersøgt 1967–1977, ses af Tabel 3, mens Fig. 2 viser koncentrationen af bly i lever og nyre. Tabel 4 viser fordelingen af blyhagl i kråser fra blyforgiftede gråænder fra Danmark og USA.

For at undersøge forekomsten af blyhagl i kråser fra gråænder, skudt på normal vis, blev der i efteråret 1975 indsamlet 3.149 kråser hos vildthandlere. Resultaterne (Tabel 5) er sammenlignet med tilsvarende fra USA, England og Sverige. I Tabel 6 er antallet af gråænder med henholdsvis optagne og indskudte blyhagl i kråserne angivet. Der fandtes i alt 77 (2,4 %) kråser med optagne hagl, hvilket er mindre end i andre lande (Tabel 5). I Tabel 7 er vist antal hagl i de undersøgte kråser.

I perioden 1971–1977 er der undersøgt 298 knopsvaner, hvoraf 78 fandtes blyforgiftede (Tabel 8). Tabel 9 viser resultaterne af 119 undersøgte og analyserede knopsvaner, mens blyindhold i lever og nyre fremgår af Fig. 3. I Tabel 10 er obduktionsresultaterne sammenlignet med tilsvarende fra USA og Canada.

Mens blyforgiftede gråænder sædvanligvis findes enkeltvis, så er det karakteristisk, at blyforgiftede knopsvaner findes samlet i større antal, og hvor en flugtskydningsbane har været placeret ved et lavvandet område (Tabel 11). Analyser af knopsvaner nedlagt nær én af disse flugtskydningsbaner efter blyforgiftningens ophør tyder på, at fuglene enten dør eller kommer fuldstændig over forgiftningen (Tabel 13). Tabel 12 viser haglforekomster i bundprøver udtaget på nogle af de i Tabel 11 omtalte lokaliteter samt fra forskellige udenlandske.

Undersøgelserne viser, at den typisk blyforgiftede gråand stammer fra opdræt; den er velnæret og har som regel hagl i kråsen og blegt muskel- og lungevæv.

Den typisk blyforgiftede knopsvane er fritlevende; den er afmagret og kønsmoden. Ved obduktion finder man hyppigt ophobning af foder i spiserør og kirtelmave samt forstørret galdeblære.

I Tabel 14 sammenlignes obduktionsresultaterne fra blyforgiftede gråænder og knopsvaner, mens Tabel 15 viser antal hagl i kråsen sammenlignet med blykoncentrationen i leveren.

Blyforgiftning som dødsårsag hos andre arter er i perioden 1967–1977 kun registreret i én fasan, én agerhøne, én ringdue, én troldand, én taffeland, én ederfugl, 2 hvinænder og 2 sangsvaner. Tabel 16 viser antallet af fugle indsendt til obduktion 1971–1977 sammenholdt med antal diagnosticerede blyforgiftningstilfælde.

Fig. 4 viser indholdet af bly i lever og nyre fra hare, ræv, husmår og musvåge samt blyindholdet i lever fra ugler, spurvehøg og tårnfalk. Med undtagelse af musvåge har de undersøgte arter alle lavt blyindhold.

Det er flere steder i udlandet påvist, at selv om blyindholdet i lever og nyre når op på så høje koncentrationer, at det medfører døden, så forbliver mængden af bly i muskulaturen på det samme relativt lave niveau, som findes i uforgiftede individer. Fig. 5 viser blyindholdet i muskulatur og lever fra blyforgiftede gråænder og knopsvaner, og det fremgår, at indholdet er lavt i musklerne, selv om fuglene er blyforgiftede.

Blyforgiftning er en af de mest almindelige dødsårsager for gråænder, der modtages til obduktion på Statens Veterinære Serumlaboratorium, idet blyforgiftning forekommer blandt 5 % af de fritlevende og 30 % af de opdrættede gråænder.

Adskillige små søer i Danmark er så kontaminerede med blyhagl, at de for øjeblikket ikke kan benyttes til gråandeopdræt.

Blyforgiftede gråænder findes over hele landet, og antallet stiger i løbet af efteråret.

Antallet af nedlagte gråænder med blyhagl i kråsen synes at ligge på et lavere niveau end i andre lande, hvorimod antallet af blyhagl i kråsen fra såvel blyforgiftede som skudte gråænder er højere. Dette underbygger den antagelse, at et relativt stort antal blyhagl er tilgængelige på

nogle af de lokaliteter, hvor fuglene får haglene i sig.

Blyforgiftning er hoveddødsårsagen blandt knopsvaner, der modtages til obduktion. Svaner med et blyindhold i leveren på 7 ppm eller mere synes at dø af blyforgiftning.

De sygelige forandringer hos blyforgiftede knopsvaner fra Danmark svarer til amerikanske og canadiske resultater, men procenten af blyforgiftede trompetersvaner med blyhagl i kråsen er lavere i USA og Canada, hvilket kan skyldes, at nogle af fuglene har fået blyet fra andre forureningskilder.

Flugtskydning over lavvandede – eller delvist oversvømmede – områder udgør en betydelig risiko for, at svømmefugle, især knopsvaner, bliver blyforgiftede. I nogle områder, hvor der drives intensiv jagt, viser haglforekomster fra bundprøver så store mængder, at svømmefugle sådanne steder vil have en stor risiko for at blive blyforgiftede.

Selv om der, bortset fra gråand og knopsvane, kun er undersøgt et mindre antal svømmefugle, synes blyforgiftning fortrinsvis at forekomme blandt de to nævnte arter. Hos andre fuglearter samt hos fritlevende pattedyr (hare, ræv og husmår) er der kun registreret lave blyindhold i leveren. Kun musvågen danner en undtagelse, idet der hos denne art er konstateret 3 tilfælde med et blyindhold over 3 ppm i leveren. De 3 musvåger kan have optaget blyet ved at fortære blyforgiftede svømmefugle eller dyr med indskudte hagl.

Undersøgelsen synes at bekræfte antagelsen af, at blyforgiftede svømmefugle ikke udgør nogen fare for konsumenterne.

Резюме на русском языке

Отравление свинцом дичи в Дании

В статье дается сводка нынешних знаний об отравлении среди водоплавающих птиц в Дании вследствие заглощения свинцовой дроби.

Исследования охватывают дичь, найденную мертвой в периоде с 1971 по 1977 г., присланную на вскрытие в Государственную Ветеринарно-Сывороточную Лабораторию. Для некоторых видов, сводка подведена с 1967 г., когда был зарегистрирован первый датский случай отравления свинцом (кряквы).

В исследовании отдельно рассматриваются вольноживущая и искусственно разведенная кряква. В периоде с 1971 по 1977 г. были обследованы всего 348 особей кряквы, из которых 70 (20%) были отравлены свинцом.

Из них 7 были оценены как вольноживущие, а 63 как искусственно разведенные (Табл. 2). Число случаев отравления свинцом повышается в течение осени (Фиг. 1). Результаты вскрытия отравленных свинцом утиных, обследованных с 1967 по 1977 г., показаны в Табл. 3, а в Фиг. 2 показана концентрация свинца в печени и почке. В Табл. 4 показано распределение свинцовых дробинок в мускульном желудке отравленной свинцом кряквы в Дании и США.

С целью изучения наличия свинцовой дроби в мускульных желудках кряквы, застреленной нормальным образом, осенью 1975 г. у торговцев дичью было собрано 3.149 мускульных желудков. Результаты (Табл. 5) сопоставлены с соответствующими из США, Англии и Швеции. В Табл. 6 указаны численности кряквы со встреленными, и соответственно с заглощенными дробинками в мускульных желудках. Было найдено всего 77 (2,4%) мускульных желудков с заглощенными дробинками, меньше чем в других странах (Табл. 5). В Табл. 7 указано число дробинок в обследованных мускульных желудках.

В периоде с 1971 по 1977 г. было обследовано 298 лебедей-шипунов, из которых 78 оказались отравленными свинцом (Табл. 8). В Табл. 9 показаны результаты обследования 119 лебедей-шипунов, а содержание свинца в печени и почке видно из Фиг. 3. В Табл. 10 результаты вскрытий сопоставлены с соответствующими из США и Канады.

Между тем как отравленная свинцом кряква обычно встречается поодиночке, характерно что отравленные свинцом лебеди-шипуны встречаются разом в значительном количестве там, где

Некоторые небольшие озера Дании до такой степени загрязнены свинцовой дробью, что они в настоящее время непригодны для разведения кряквы.

Отравленная свинцом кряква встречается по всей стране, и ее количество возрастает в течение осени.

Кажется, что количество убитой охотниками кряквы со свинцовой дробью в мускульном желудке находится на более низком уровне, чем в других странах, но за то количество дроби в мускульном желудке, как у отравленной свинцом, так и у застреленной кряквы более высоко. Это обосновывает предположение о том, что относительно большое количество дроби доступно в тех местностях, где птицы заглатывают дробь.

Отравление свинцом является главнейшей причиной смерти принимаемых на вскрытие лебедей-

шипунов. Кажется, что лебеди с содержанием свинца в печени в 7 частей на миллион или более, погибают от отравления свинцом.

Болезненные изменения у отравленных свинцом лебедей-шипунов из Дании соответствуют обнаруженным в США и Канаде, но процент отравленных свинцом американских лебедей, имевших в мускульном желудке свинцовую дробь, в США и Канаде значительно ниже, что может объясняться тем, что некоторые из птиц заглотили свинец из других источников загрязнения.

Стрельба по летяшей мишени над мелководными - или частично наводненными - пространствами создает значительный риск отравления свинцом водоплавающих птиц, особенно лебедей-шипунов. В некоторых районах, где ведется интенсивная охота, пробы дна содержат такие большие количества дроби, что водоплавающие птицы в таких местах подвержены значительной опасности отравления свинцом.

Хотя за исключением кряквы и лебедя-шипуна было обследовано только небольшое число водоплавающих птиц, кажется что отравление свинцом главным образом встречается у этих двух упомянутых видов. У других видов птиц, а также у дикоживущих млекопитающих (зайца, лисицы и каменной куницы) зарегистрированы только невысокие содержания свинца в печени. Только сарыч представляет собой исключение, так как у этого вида обнаружено 3 случая с содержанием свинца в печени, превышающим 3 части на миллион. Возможно, что эти 3 сарыча заглотили свинец, пожирая отравленных свинцом водоплавающих птиц или животных со встреленными дробинками.

Кажется, что исследование подтверждает предположение того, что отравленные свинцом водоплавающие птицы не представляют опасности для потребителей.

около мелководного пространства расположено стрельбище для стрельбы по летящей мишени (Табл. 11). Анализы лебедей-шипунов, убитых вблизи таких стрельбищ после окончания отравления свинцом, дают основание предполагать, что птицы либо умирают, либо совершенно выздоравливают от отравления (Табл. 13). В Табл. 12 указаны находки дроби в пробах дна, выбранных в некоторых из указанных в Табл. 11 местностей, а также из разных заграничных.

Исследования показали, что типичная отравленная свинцом кряква происходит из искусственно разведенных птиц; она откормлена, обычно имеет дробинки в мускульном желудке, и бледную мышечную и легочную ткань.

Типичный отравленный свинцом лебедь-шипун - вольноживущий; он исхужденный и половозрелый. При вскрытии часто обнаруживается накопление корма в пищеводе и железистом желудке, и увеличенный желчный пузырь.

В Табл. 14 сопоставлены результаты вскрытий отравленных свинцом крякв и лебедей-шипунов, а Табл. 15 указывает количества дробинок в мускульном желудке по сравнению с концентрацией свинца в печени.

Как причина смерти других видов, отравление свинцом в периоде с 1967 по 1977 г. зарегистрировано только у одного фазана, одной куропатки, одного вяхиря, одной хохлатой чернети, одного красноголового нырка, одной гаги, двух гоголей и двух лебедей-кликунов. В Табл. 16 указано число птиц, присланных на вскрытие с 1971 по 1977 г., сопоставленное с числом диагностицированных случаев отравления.

В Фиг. 4 показано содержание свинца в печени и почке от зайца, лисицы, каменной куницы и сарыча, а также содержание свинца в печени от совы, перепелятника и пустельги. За исключением сарыча, содержание свинца у всех обследованных видов было незначительно.

В нескольких других странах доказано, что даже если содержание свинца в печени и почке достигает смертоносно высоких концентраций, количество свинца в мускулатуре остается на таком-же относительно низком уровне, как у неотравленных особей. Фиг. 5 указывает содержание свинца в мускулатуре и печени отравленных свинцом крякв и лебедей-шипунов, и очевидно, что содержание его в мышцах невысоко, хотя птицы отравлены свинцом.

Отравление свинцом является одной из самых обычных причин смерти кряквы, принимаемой для вскрытия Государственной Ветеринарно-Сывороточной Лабораторией, так как отравление свинцом встречается у 5% вольноживущих и 30% искусственно разведенных крякв.

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