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Lead Pellets in Tissues
of Mute Swans (*Cygnus olor*)
from Denmark

by

PELLE ANDERSEN-HARILD, BJARNE CLAUSEN,
KARI ELVESTAD AND NIELS OTTO PREUSS

Med et dansk resumé:
Blyhagl i danske knopsvaner
(*Cygnus olor*)

Резюме на русском языке:
Свинцовые дробинки в датских
лебедях-шипунгах (*Cygnus olor*)

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Abstract

X-ray photography of 552 Mute Swans collected in Denmark during 1975-1979 revealed that 14% contained lead pellets in their tissues.

There were considerable geographical differences in the proportions, varying from 23% in Jutland, 22% in Northern Sealand, 13% in Southern Sealand to 6% in Lolland-Falster. The highest percentages of Mute Swans containing pellets derive from regions where the species is mainly resident, and spends most of the year in Denmark.

Introduction

Complete protection of the Mute Swan (*Cygnus olor*) in Denmark was introduced in 1926. Since then the breeding population has increased from 3-4 pairs to nearly 3000 pairs in 1966 (BLOCH 1971). Furthermore up to 35,000 individuals moult, and 40,000-70,000 overwinter in Danish waters, stressing the specific importance of these waters for the Baltic population (ANDERSEN-HARILD 1971, JOENSEN 1974, FERDINAND 1980).

For many years the Mute Swan has also been protected in Norway, Sweden, Finland, USSR, Poland, the German Democratic Republic, the German Federal Republic (except in Schleswig-Holstein where an open season in September was introduced in 1977), and the Netherlands. The Whooper Swan (*Cygnus cygnus*) and Bewick's Swan (*Cygnus columbianus bewickii*) have also been protected in Denmark for many years as well as in the above-mentioned countries.

In England illegal shooting of swans has been reported by OWEN & CADBURY (1975) who found that 8% (10 out of 128 swans, comprising all three species) found dead in eastern England were killed by shooting. EVANS et al. (1973) X-rayed 282 live Bewick's Swans caught in 1970-1972 at Slimbridge, and found that 34% contained lead pellets.

Whether shooting of swans also occurs in Denmark has been the subject of discussion. The present survey was initiated to elucidate the extent to which Mute Swans found in Denmark contain pellets in their tissues as signs of previous shooting. As pellets are found only occasionally on autopsy, the frequency of birds containing pellets in tissues could only be determined by X-ray.

X-ray surveys have been carried out in

other countries to determine the frequency of waterfowl containing pellets in tissues (ELDER 1955, HOFFMAN 1965, EVANS et al. 1973), but so far no such investigations have been made in Denmark.

Materials and methods

The present paper is the result of teamwork between the State Veterinary Serum Laboratory and the Zoological Museum, Copenhagen, and both institutes have collaborated in collecting the material.

The Mute Swans analysed were collected during two periods and partly in two different ways. Only individuals found dead were included, as birds which died exclusively from shooting would give a serious bias. The latter were excluded from this study.

June 1st 1975 - January 31st 1977: During this period 112 dead Mute Swans were X-rayed (Table 1), including all 22 ringed and 90 unringed. No special criterion was used concerning selection of the latter. The State Veterinary Serum Laboratory received some birds (mainly those from the summer period) as part of its general work concerning autopsy of wild birds and mammals found diseased or dead. The remainder, including nearly all those from the winter period, were collected for biological studies, and for analyses of lead poisoning.

January - March 1979: During the severe winter, large numbers of Mute Swans died, mainly due to starvation. Of these, 2,111 were collected for various examinations. For X-ray surveys all 173 ringed birds from the whole country (except for a few whose decay was advanced), and all 19 unringed birds from Jutland were selected. Additionally another 248 unringed birds of no special status were selected,

Period	Area										All areas		
	A		B		C		D		E				
	a	b	a	b	a	b	a	b	a	b	a	b	b in %
April-December 1975-1977	10	4	10	2	36	4	1	0	1	0	58	10	17
Jan.-March 1975-1977	5	2	0	0	41	9	0	0	8	0	54	11	20
Jan.-March 1979	25	5	1	0	35	8	277	35	102	7	440	55	13
Total winter	30	7	1	0	76	17	277	35	110	7	494	66	13
Total whole year	40	11	11	2	112	21	278	35	111	7	552	76	14

Table 1. Distribution of 552 X-rayed Mute Swans according to area and period of collection.

A: Jutland. B: Funen. C: Northern Sealand. D: Southern Sealand and Møn. E: Lolland-Falster. a: No. of swans X-rayed. b: No. of swans carrying pellets.

totalling 440 specimens (Table 1). The majority of the latter came from south-east Denmark. In western Denmark the number of wintering Mute Swans was much smaller, and the proportion of birds dying from starvation evidently lower than in eastern parts. This, together with difficulties in collecting birds and subsequently arranging transport to Copenhagen resulted in few birds from these areas being included.

As the time and procedure of collecting during winter only differed slightly between 1975-1977 and 1979, the data ob-

tained are sufficiently homogenous to be considered together. Analyses between geographical areas of differences in the frequency of swans carrying pellets in tissues were made only on material from the winter period. The material from the summer period was too small for such analyses.

For taking the X-rays a Philip Maximus 100 camera 60 kV in 35 mAs was used. Two or three shots (Gevaert Cruis R P I 30x40 cm) were needed to cover each swan. After X-raying the birds were sexed and autopsied, and if possible pellets indi-

Cause of death	Area										All areas	
	A		B		C		D		E			
	a	b	a	b	a	b	a	b	a	b	a	b
Starvation	9	3	3	0	30	8	245	33	84	5	371	49
Injury	8	1	2	1	25	4	6	1	3	1	44	8
Lead poisoning	19	7	4	0	29	7	3	0	8	0	63	14
Infection	1	0	2	1	13	2	8	1	7	1	31	5
Other causes*	3	0	0	0	15	0	16	0	9	0	43	0
Total	40	11	11	2	112	21	278	35	111	7	552	76

Table 2. Cause of death of 552 Mute Swans in relation to area. (For explanation of symbols see Table 1).

*: include 8 specimens with traumatic indigestion, 4 with urine acid (gout), 1 with oil and 30 where no cause of death could be stated, or where birds were too decayed for autopsy.

cated on the X-rays were removed and their position in the corpse recorded. Only when different sizes of pellets were found in the same specimen, was it recorded as shot twice. Whenever possible the cause of death was determined (Table 2).

Geographical distribution

For several years Mute Swans have been ringed in Denmark during the moulting period as well as during winter.

Analyses of ringing-recovery data indicate that Mute Swans occurring in Danish waters can be divided into five fairly separate populations (ANDERSEN-HARILD 1981

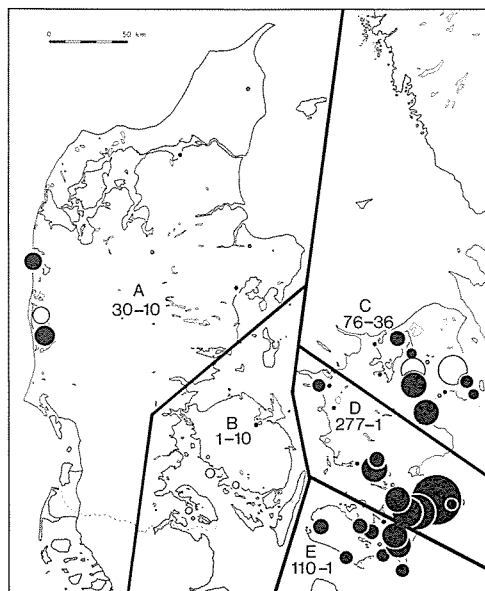


Fig. 1. Localities where Mute Swans were collected for X-raying during 1975-79. A = Jutland, B = Funen, C = Northern Sealand, D = Southern Sealand and Møn, E = Lolland-Falster.

The number of Mute Swans collected during winter (Jan.-March) is indicated by the first figure; the second figure indicates the number collected during »summer« (April-December).

● = collected during winter, ○ = collected during »summer«. The area of each circle corresponds to the number of swans collected.

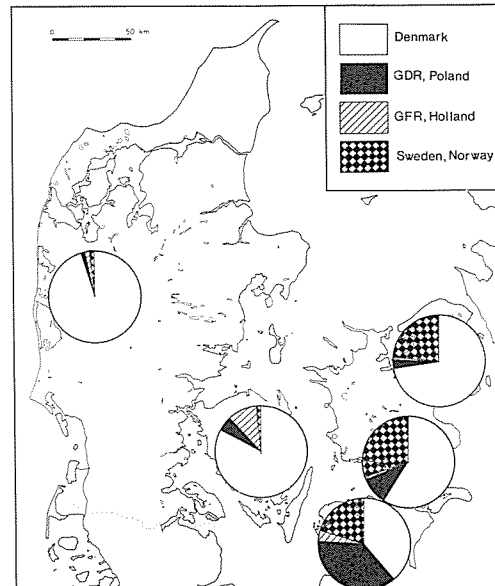


Fig. 2. The origin of Mute Swans ringed in five different areas in Denmark.

a and Fig. 1) and therefore the birds X-rayed are grouped accordingly (Fig. 2).

A. Jutland: The material includes swans primarily from fiords in western Jutland. These birds are mostly sedentary, as indicated by the distribution of the recoveries, where 96% are from Denmark. Some Swedish swans winter in fiords of eastern Jutland (especially Mariager Fiord and the Liim Fiord), but very few from these areas were autopsied.

B. Funen: Swans from this region are mostly sedentary, 83% of the recoveries being from Denmark. Some individuals from Schleswig-Holstein, West Germany, winter here.

C. North Sealand: Of the recoveries of swans ringed in this region, 72% are from Denmark and 25% from Sweden. The breeding population in this region has been studied in great detail and found mainly resident.

D. Southern Sealand and Møn: In this region 59% of the recoveries come from Denmark, 30% from Sweden and 11% from Poland and East Germany.

E. Lolland-Falster: In this region 39% of the recoveries come from Denmark, 20% from Sweden, 35% from Poland and East Germany and 6% from West Germany.

The migration pattern demonstrates that many swans from Poland and East Germany moult and/or winter in south-eastern Denmark. Swedish birds occur throughout Sealand, while in Funen and Jutland only very few foreign swans occur.

No attempt has been made to analyse the geographical distribution at different times of year. It may be mentioned, however, that most swans from abroad leave Denmark during spring and summer. The Mute Swan seldom changes its winter quarters (ANDERSEN-HARILD 1970) and 91% of all ringed birds in the present material were found in the area where originally ringed.

Age and sex of X-rayed swans

According to plumage, birds were divided into two age-groups:

1. More or less grey specimens: less than one-year old (young).
2. White specimens: older than one year.

The proportion of young birds in the sample varied from 2% to 6% among regions.

The sex-ratio was nearly equal in Jutland (49%), but males were predominant in samples from other regions (58-62%).

Ringed Mute Swans

In the total material, 35% (195) of the swans were ringed, varying from 15%

Age Years	No. with exact age	No. with minimum age
0-1	15	-
1-2	5	-
2-3	3	49
3-4	6	10
4-5	9	12
5-6	12	6
6-7	7	9
7-8	3	10
8-9	1	7
9-10	-	5
10-11	1	4
11-12	-	18
12-13	-	-
13-	2	1
Total	64	131

Table 3. Age of 195 ringed Mute Swans.

(Jutland) to 54% (Northern Sealand). Of the ringed individuals 64 could be aged precisely, whereas only a minimum age could be given for the remaining 131 birds because they were ringed as white swans (Table 3). Of the latter, 49 were ringed in the same winter as they were found dead and thus could not provide more information than unringed white birds.

The mean age of the ringed swans of precise age was 4.3 years in Lolland-Falster, 5.0 in Southern Sealand and Møn, 5.3 in Northern Sealand and 5.8 in Jutland.

As ringing efforts have differed from region to region and from year to year, the age-composition of the ringed birds is not necessarily representative for the entire material, and ringed birds may cause a bias in the age distribution.

However the calculated mean ages do not differ much from the mean age of 4-5 years for the total population (ANDERSEN-HARILD 1978), except for Jutland, where a slightly lower mean age might be expected, as the mortality rate for this popula-

Lead Pellets in Tissues of Mute Swans

No. of pellets	1	2	3	4	5	6	8	9	10	15	20	26
No. of birds	39	7	4	6	2	1	6	1	3	1	1	1
%	54	26			15			4				

Table 4. Number of pellets in 71 Mute Swans. One bird with pellets measuring 3 mm and 4 mm respectively was counted twice.

tion is a little higher than for other populations (ANDERSEN-HARILD unpubl.).

Results

Of the 552 swans X-rayed 76 (14%) carried shotgun pellets (Fig. 3), airgun pellets (Fig. 4) or rifle bullets in their tissues. Of the specimens carrying lead pellets one had two sizes of pellet, three had shotgun pellets as well as airgun pellets, one had a 6 mm rifle bullet and shotgun pellets (Fig. 5), and one had a bullet only. As five birds were hit at least twice, the 76 individuals which had been shot at therefore represent a minimum of 81 shooting incidents, comprising 72 with shotguns, 7 with airguns and 2 with rifles. It was found that 25 (13%) of the ringed swans carried pellets, compared to 51 (14%) of the unringed birds.

Of the 76 swans shot at, 66 (13%) derived from the 494 specimens collected during the winter period and 10 (17%) from 58 individuals found during the rest of the year (Table 1).

In 71 swans containing shotgun pellets a total of 253 pellets were found, corresponding to an average of 3.6 per bird.



Fig. 3. X-ray of the hind part of a Mute Swan hit by 20 pellets, of which 14 can be seen. The bird survived shooting and died later from lead poisoning after ingesting pellets. In the paralysed gizzard some small worn lead pellets can be identified.

The distribution is such that 54% contained only one pellet, and 4% more than

Diameter of pellets (mm)	2.0	2.5	3.0	3.25	3.5	4.0	4.25	4.5
No. of birds	4	10	18	4	1	6	1	1

Table 5. Diameter of pellets removed from 44 Mute Swans. One bird contained both 3 and 4 mm pellets.

Part of bird	%	Hit from dorsal side	Hit from ventral side	Direction impossible to state
Head	10	-	4+1*	4+1*
Neck	27	1	9+1*	13+4*
Body	24	2	7	13+1*+1•
Tail	6	1	-	5
Wings	23	2	4	16+1•
Legs	11	1	1	8+1*
Total	101	7	27	68

Table 6. The position of 102 pellets found in Mute Swans. When a bird was hit with more than one pellet, each part of the bird was recorded.

* = airgun pellets. • = bullets.

10 (Table 4). The birds therefore have probably been fairly far away from hunters when hit. EVANS et al. (1973) found in Bewick's Swans an average of 3.2 pellets per bird, 37% containing a single pellet.

The pellets were removed from 44 corpses and the diameter measured (Table 5). Most of the pellets were small, indicating that the hunters did not primarily intend to shoot swans.

When removing pellets their position was noted and when possible also their direction of entry (Table 6). This informa-

tion indicates that birds have often been shot at during flight.

Pellets are found more often in males than in females (Table 7). An uneven sex-ratio is common among swans, males being predominant. This was also the case for the X-rayed sample, where 59% were males. Nevertheless, 55 (72%) of the birds with pellets were males, which is significantly different from the expected distribution ($p < 0.05$). Also among Bewick's Swans, more males carried lead pellets than females (EVANS et al. 1973).

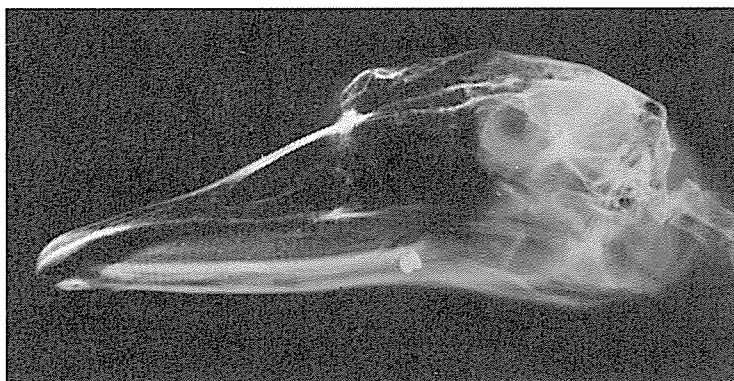
Sex	♂	♀	?	Total
Without pellets	259	197	20	476
With pellets	55	20	1	76
Total	314 (59%)	217 (41%)	21	552

Table 7. Number of Mute Swans with pellets in relation to sex.

Minimum age in years	0-1	2-4	5-8	≥ 9
No. of birds	26	94	55	31
Without pellets	No. 25	86	47	23
With pellets	No. 1 % 4	8 9	8 15	8 26

Table 8. The frequency of pellets in relation to minimum age of ringed Mute Swans. Eleven unringed birds are included in the age group 0-1 year.

Fig. 4. X-ray of the head of a Mute Swan with an airgun pellet, which apparently did not harm the bird. It later died from starvation during the winter of 1978-1979.



As regards age, the proportion of swans with pellets increases from 4% in young ones to 26% in birds older than 8 years (Table 8).

Discussion

The analyses show remarkable geographical differences in the percentage of swans containing pellets (Table 9). The lowest percentage occurs from Lolland-Falster (6%), increasing to Southern Sealand and Møn (13%), Northern Sealand (22%) and Jutland (23%). The observed distribution is significantly different from that expected if the frequency of birds carrying pellets was equal in each area ($\chi^2 = 12.66$; $df = 3$; $p = 0.005$ in a two-tailed test).

The explanation for the differences may be found in differences in the sex-composition between the areas. Males

carry pellets more frequently than females (Table 7). This may be due to differences in size between the sexes; males are bigger than females, and this will on average give the hunter a larger target. The small difference in size cannot however be the complete explanation for why relatively more males are hit than females.

It is presumed that most birds are hit in coastal waters where the most intensive waterfowl hunting occurs. As females in general are younger than males when they start breeding (ANDERSEN-HARILD 1981b) and therefore move to fresh-water habitats at an earlier age, this may partly explain why males are more frequently a target for hunters than females. Another explanation may be the difference in moult. In breeding swans the male moults after the female, and thus males will mostly be flightless in August-October,

Area	No. X-rayed	With pellets		Recoveries from Denmark %
		No.	%	
A Jutland	30	7	23	96
B Funen	1	0	-	83
C Northern Sealand	76	17	22	72
D Southern Sealand and Møn	277	35	13	59
E Lolland-Falster	110	7	6	39
Total	494	66		

Table 9. Relation between area of collection and the percentage of Mute Swans carrying pellets, compared with the percentage of recoveries from Denmark of Mute Swans ringed in the five areas.



Fig. 5. X-ray of the forepart of a Mute Swan with 4 shotgun pellets and one rifle bullet in the tissue. To the left, note the paralysed proventriculus and gizzard filled with sand and aquatic plants. The paralysis was caused by lead poisoning; the bird died after ingestion of lead pellets.

when waterfowl hunting has started, but other unknown factors may be involved, e.g. behavioural differences between the sexes.

However, as the percentage of males is nearly the same in the areas of Northern Sealand (C), Southern Sealand and Møn (D) and Lolland-Falster (E), the observed difference between the sexes cannot be explained in this way. In Jutland the percentage of males is lower, and this should indeed result in the shooting percentage being comparatively low.

The frequency of birds with pellets increases with age (*Table 8*). There is no reason to expect the occurrence of any significant differences in the age-composition of the regional samples except for Jutland, where as already mentioned the

mean age of the population is expected to be a little lower than in other regions. This should however result in a comparatively lower percentage of birds shot at.

Thus there is no reason to believe that the differences in proportions of swans containing pellets are caused by differences in sex- and/or age-composition. It is therefore most likely that the observed differences reflect a different rate of shooting at swans occurring in various parts of Denmark.

Legitimate shooting of Mute Swans in Denmark can only take place following the issue of a special permit by the Ministry of Agriculture. Such permits are seldom issued and so far only to airport authorities. In all cases rifles were used and no wounding is known to have occurred.

The only area near Denmark which has an open season for Mute Swans is Schleswig-Holstein, West Germany. It was introduced in 1977, but only for the month of September, and the annual bag is presumed to be small. Since 1977 only one Danish ringed Mute Swan has been reported shot in Schleswig-Holstein. This in combination with the fact that only a small fraction of the Danish population occurs in Schleswig-Holstein (*Fig. 2*) cannot explain the high proportion of swans with pellets as a result of the open season there.

From *Table 9* it is seen that the lower the proportion of resident Danish birds in a given area, the lower the percentage of birds with pellets. For instance only 39% of the birds ringed in Lolland-Falster are later recovered in Denmark. Most of the population from this area occur outside Denmark in September-November, when waterfowl hunting is commonest in Denmark. Only 6% of the birds collected in this area had pellets in tissues. From Northern Sealand 22% contained pellets and it is known for this area that 72% of

the birds are later recovered in Denmark.

Among the birds from here which contained pellets 8 were ringed. As they were ringed within an area where the Mute Swan population is intensively studied, repeated controls have proved that 7 of these birds were locally resident birds and that the last one spent at least 2 winters within the area.

Swedish Mute Swans, which to some extent are found in Northern Sealand are known to spend most of the year in Western Sweden. The frequency of birds with pellets in tissues in Western Sweden is found to be 6% (S. MATHIASSEN pers. comm.).

This strongly indicates that most of the illegal shooting takes place in Denmark. Also the fact that 10% (31 of 301) of the swans found dead and sent in for autopsy at the State Veterinary Serum Laboratory during 1971-1978 are killed by shooting (CLAUSEN unpubl.), indicates considerable shooting at this species in Denmark.

If shooting has an additional influence on the later cause of death it would be expected that swans recorded dead from injury or infection more frequently contain pellets than birds dead from other causes. Only birds dying from lead poisoning apparently more often contain pellets (Table 2), maybe because these birds are found in areas with the most intensive hunting. From the distribution, however, it is not possible to find any difference to support the view that there is a correlation between pellets in tissues and the cause of death. It seems that pellets have no permanent effect on birds which survive shooting. Lead pellets in tissues do not have any effect on lead levels in muscles and organs (CLAUSEN et al. 1979).

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Dansk resumé

Blyhagl i danske knopsvaner (*Cygnus olor*)

For at undersøge i hvilket omfang den gennem mere end 50 år totalfredede knopsvane er genstand for beskydning, er der foretaget røntgenundersøgelser af 552 dødfundne individer. Af disse er 112 indsamlet i perioden 1. juni 1975 - 31. januar 1977, mens de øvrige 440 stammer fra januar-marts 1979 (Tabel 1 og Fig. 1). Svaner, der var døde i umiddelbar tilknytning til en beskydning, indgår ikke i analysen.

Dødsårsagen for de undersøgte svaner er så vidt muligt bestemt (Tabel 2).

Røntgenundersøgelserne viste, at 76 svaner (14%) havde hagl i kroppen. I 71 af disse registreredes ialt 253 hagl, svarende til 3,6 stk. pr. fugl. 54% havde kun 1 hagl hver, og 4% mere end 10 hagl hver (Tabel 4). De fleste beskydninger er foretaget med 2,5 og 3,0 mm hagl (Tabel 5), og formodentlig på flyvende fugle (Tabel 6).

Hanner har relativt oftere hagl i sig end hunner (Tabel 7). Årsagen hertil har ikke kunnet forklares fyldestgørende, men forskelle i blandt andet størrelse, ynglebiologi, fældningstidspunkt og adfærd kan være medvirkende.

Opdeling af svaner med kendt alder viser, at blandt 0-1 årige svaner har 4% hagl i sig, stigende til 26% for fugle, der er mere end 8 år (Tabel 8).

Der er betydelig forskel fra landsdel til landsdel i andelen af knopsvaner, der har hagl i sig. Færrest forekommer i fugle fra Lolland-Falster (6%), dernæst Syd-Sjælland og Møn (13%), Nord-Sjælland (22%) og Jylland (23%). Forskellen er korreleret med de enkelte områders andele af standfugle, således at jo større procentdel danske fugle et område indeholder, jo større er beskydningsfrekvensen (Tabel 9). Det må derfor antages, at hovedparten af de beskydninger, knopsvaner har været ude for, har fundet sted i Danmark.

Резюме на русском языке:

Свинцовые дробины в датских лебедях-шипунях (*Cygnus olor*)

Для выяснения того, в какой степени полностью охраняемые в течение более 50 лет лебеди-шипуньи подвергаются обстрелу, было произведено рентгенографическое исследование 552 особей, найденных мертвыми. Из них 112 собрано в периоде с 1 июня 1975 г. по 31 января 1977 г., а остальные с января до марта 1979 г. (Табл. 1 и Фиг. 1). Анализ не охватывает лебедей, погибших в непосредственной связи с обстрелом.

Поскольку это было возможно, определялась причина смерти обследованных лебедей (Табл. 2).

Рентгенографические исследования показали, что у 76 лебедей (14%) в телах были дробины. У 71 из них были обнаружены 253 дробины, что соответствует 3,7 шт. за птицу. У 54% было только по одной дробиночке, а у 4% более чем по 10 дробинок (Табл. 4). Большинство обстрелов было дробью в 2,5 и 3,0 мм (Табл. 5), и можно предполагать, что охотники обстреливали птиц налету (Табл. 6).

Самцы содержат дробины сравнительно чаще, чем самки. Причину этого не было возможно удовлетворительно объяснить, но содействующими обстоятельствами могут быть различия в, между прочим, величине, биологии размножения, времени линьки и поведении.

Подразделение лебедей по известному возрасту показывает, что дробины найдены в 4% лебедей возрастом от 0 до 1 года, и что процент возрастает до 26% у птиц старше 8 лет (Табл. 8).

Доля лебедей, содержащих в себе дробины, значительно неодинакова у птиц из разных частей страны. Меньше всего дробинок обнаружено в птицах с островов Лоланн и Фальстер (6%), затем следуют Южная Зеландия и остров Мён (13%), Северная Зеландия (22%) и Ютландия (23%). Эта разница корреляционна с долями общей оседлой популяции этих птиц, обитающими в данных районах: чем более значительный процент датских птиц находится

в районе, тем выше частота обстрелов (Табл. 9). Следовательно имеется основание предполагать, что большинство обстрелов, которым подвергались лебеди-шипуньи, произошло в Дании.

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