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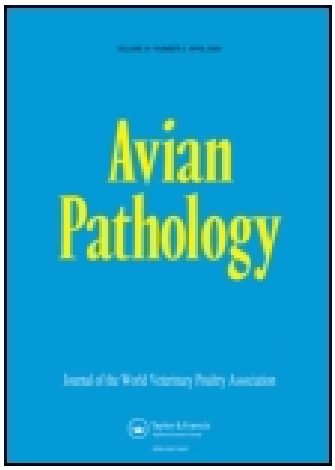

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A survey of blood lead levels in Mute Swans Cygnus olor

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A survey of blood lead levels in Mute Swans *Cygnus olor*

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Following bans on the use of most lead angling weights, the incidence of lead poisoning cases in Mute Swans started to fall and the population started to increase. However, surveys of lead levels in blood of rescued swans continue to show that a high proportion of the birds are carrying levels in excess of 1.21 mol/l. Since rescued swans, although rescued for many different reasons, might be a biased sample, a survey was made of apparently healthy birds living in flocks in the summer. These too showed that a high percentage of the birds in most of the flocks sampled had blood lead levels in excess of 1.21 mol/l. No source of this lead has been identified other than lead fishing weights; these may be long-lost leads, current, but illegally used weights or "dust-shot" which it is still legal to use. Although many of the birds sampled are carrying lead burdens that are probably not harmful, others are seriously affected. Except in the most serious cases, it is not possible to recognise birds with elevated lead levels without taking a blood sample for assay.

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Introduction

Lead poisoning of Mute Swans *Cygnus olor* was a very serious cause of mortality in the 1960s, 1970s and early 1980s. A UK Government report (Goode, 1981) which high-lighted the seriousness of the situation estimated that as many as 4000 swans might be dying annually as a result of lead poisoning. As a result of this report, the importation and sale of lead weights between 0.06 and 26.5 g was banned in the UK in 1987 and subsequently the use of the same weights was banned by the Regional Water Authorities in England and Wales. There was a sharp reduction, in most areas at least, in the numbers of swans dying or very sick from, lead poisoning (Owen, 1992).

Despite this, elevated lead levels remain a fairly common clinical problem for many of the swans admitted to rehabilitation centres across the country. Elevated blood lead levels were found in a high proportion of the rescued birds seen by Swan Rescue in the Worcester area and some of these readings were very high indeed (Waine, 2000).

This paper presents data from three rehabilitation centres, including that reported on by Waine (2000). The three centres regularly, or routinely, test swan admissions for lead. The birds were admitted for a wide variety of reasons, but generally because they required care and attention. The data thus obtained provide a useful picture of the blood levels in a small, but important, subsection of the national population. However, since these birds were brought in for a variety of causes (including lead poisoning) they are unlikely to be wholly representative of the national flock. One of the aims of this study was, therefore, to take blood samples from birds in a range of flocks. Thus was done during the summers of 2000 and 2001.

In considering the impact of lead poisoning on the swan population it is important to recognise that it is not possible to equate a specific blood

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level with a healthy normality. Toxicity, demonstrated by overt clinical signs can be seen at a range of lead concentrations (Royal Society for the Prevention of Cruelty to Animals, RSPCA, unpublished data), whilst the effects of chronic exposure are much harder to document. In this paper, measurements are given in μmol/l, which is the normal standard now used in Europe and many other parts of the world (Reports of lead poisoning may be confusing in that lead levels are reported in a variety ways: ppm (parts per million), μg/100 mls or μg/dl (micrograms per 100 millilitres or per decilitre) or μmols/100 mls or μmol/l (micromols/100 mls or litre). 20 μg/100 mls = 0.2 ppm and is approximately equal to 2 μmol/l). In the case of swans and other waterfowl the level of 1.93 μmol/l (0.40ppm) has been used (Degernes *et al.*, 1989). More recently a stricter level of 1.21 μmol/l (0.25 ppm) has been used to indicate that the birds had elevated blood levels; there is no legal level for birds, but this is similar to that for adult cattle (Allen, 1992).

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Materials and Methods

Two types of data are presented: rescue centre data and wild bird data

Rescue centre data

Data were obtained from three rescue/rehabilitation centres serving three distinctly different geographical areas. Generally speaking these results are based on surveys of rescued swans and so are likely to be biased towards higher lead levels. Nevertheless a substantial number of these birds are rescued because of injuries unrelated to lead. The three studies are as follows:

i. Wychbold Swan Rescue, Worcestershire receiving an average of 300 Mute Swans per annum, drawn from a catchment area that includes Staffordshire, West Midlands, Warwickshire, Worcestershire, Herefordshire and parts of Gloucestershire and Shropshire. Some of the results of this study have been reported elsewhere (Waine, 2000). Ideally, all swans admitted were to be sampled for diagnostic purposes except for: cygnets, where it was judged that the additional handling might endanger the life of a critically ill birds or those requiring only minor treatment (e.g. removal of fishing hooks from the skin) and prior to release on site. In practice, organisational problems meant that only about 70% of suitable subjects were tested. One ml of blood was taken, on or soon after admission, from either the jugular or the medial metatarsal vein using a 2.5 ml syringe and a 21 g 5/8 inch needle, put into and EDTA tube and dispatched within 48 hours to the Central Animal Pathology Laboratory, Keele.

ii. The RSPCA Wildlife Hospital, West Hatch, Somerset receiving approximately 100 to 150 Mute Swans per annum, drawn from a catchment area that extends from Cornwall and Devon, across the Somerset levels to Gloucestershire, Wiltshire and South Wales. These South West regions had not hitherto been thought to be areas where the incidence of lead poisoning was high. This report covers swans sampled between June 1994 and September 2001. Almost all swans admitted to the hospital are tested for blood lead levels, the samples being taken on, or close to, admission. Swans were identified by a unique admission number on admission and a British Trust for Ornithology leg ring when mixed with other swans. They were restrained in a specially designed swan bag, allowing easy access to either leg. One ml samples were obtained from the medial metatarsal leg vein and the blood was put into lithium heparin or EDTA tubes and submitted for testing to the Veterinary Laboratories Agency (VLA), Shrewsbury or Greendale Laboratories, Surrey for measurement of blood lead levels.

iii. The RSPCA Wildlife Hospital, Stapeley Grange, Cheshire receiving swans from an area largely in the west Midlands. The sample reported is of swans rescued between September 1998 and December 1999. Swans admitted to the hospital were routinely blood sampled on admission and tested for blood lead levels as at West Hatch.

Wild population data

Eleven sites were chosen where there were regularly flocks of birds and where the background levels of lead were expected to differ greatly (Figure 1). These ranged from heavily fished locations with a history of lead poisoning (e.g. Stratford, Hampton) to places with little or no fishing activity where it was thought unlikely that there would be significant amounts of lead in the environment (e.g. Christchurch, Abbotsbury, Slimbridge).

All samples were taken from flocks during July to September (except for one in February), which is the period of the post-breeding moult. This period was chosen because the then flightless birds would have been living at that site for some weeks and not just flown in from elsewhere. The swans were caught and blood sampled (under a Home Office Licence) at eleven sites in summer 2000, at Windsor again in February 2001 and Stratford and Abbotsbury, also for a second time, in July 2001. At Abbotsbury only birds raised in the colony were selected so as to increase the probability that the birds sampled had been living there for a long time; ringing and re-sighting data show that most of these birds never leave the Fleet adjacent to Abbotsbury in their lives.

The birds were all caught by attracting them to food except at Christchurch and Slimbridge where they were rounded up. The birds were selected as randomly as possible, but there are always potential biases and taking a truly random sample of birds from the free-living flocks is probably impossible. Catching birds to food inevitably means that the hungriest or boldest are most easily caught. By contrast, sick birds are less likely to be caught by attracting them to food in the manner described, though in the early stages of lead poisoning, birds may be hungry.

The sites where the swans were sampled were (the numbers in brackets are the approximate number of birds in the flock and the number blood-sampled, respectively), (Figure 1):

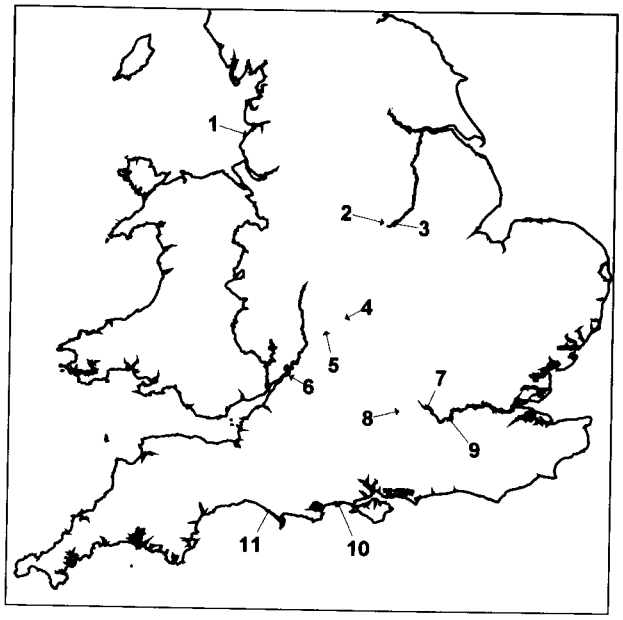

Figure 1. *The positions where wild Mute Swans were sampled: 1, Southport, 2, Nottingham, 3, Colwick Park, 4, Bewdley, 5, Stratford, 6, Slimbridge, 7, Windsor, 8, Reading, 9, Hampton, 10, Christchurch, 11, Abbotbsury.*

1. Stratford-on-Avon (R. Avon, Warwickshire). (100: 20, 21 in July 2001). A large flock on a heavily-fished river with a history of lead poisoning. Part of the area around the flock is now a no-fishing area.
2. Bewdley (R. Severn, Worcestershire) (40:10). A town flock living in a well-fished river.
3. Hampton-on-Thames, (R. Thames)(100:21). Heavily fished part of the river, but a no-fishing zone immediately around the flock.
4. Windsor, (R. Thames) (200:20, 15 in February 2001). A large population with little fishing in the immediate vicinity.
5. Reading, (R. Thames) (200:20). A large flock, with a no-fishing area in the immediate vicinity.
6. Southport, (Marine Lake, Lancashire (100:18). A large lake within the town, fairly polluted, but little fished.
7. Christchurch, (R. Avon, Hampshire) (400+:15). A large moulting flock in a brackish area traditionally free from lead poisoning; only sea-angling occurs in the immediate vicinity of the flock.
8. Abbotsbury (The Fleet, Dorset) (800:15, 21 in July 2001). A colony in an area free of fishing, but has been shot over in the past.
9. Colwick Park, (Lake, Nottingham) (50:9). A dispersed flock. Some fishing on the lake.
10. Nottingham, (R.Trent) (50:6). The river within the city of Nottingham.
11. Slimbridge, (Gloucestershire) (150:27). A large moulting flock within the Wildfowl and Wetlands Trust grounds. Free of fishing, but some of the birds move in and out of the grounds.

Sample collection

Swans were restrained by tying the wings and legs with crepe bandages. The blood samples (at least 1 ml) were taken from the brachial vein (using a 2.5 ml syringe and a 21 gauge needle) and immediately placed into heparinised tubes. The brachial vein was used because the author has found it easy to do this single-handed. Also, in cold conditions, a greater blood pressure can be expected within the brachial vein, compared with the medial metatarsal vein. When swans are in water, or on land in cold conditions, circulation to the feet is poor due to the rerouting of venous blood away from the featherless extremities. The birds were weighed, measured (head length), aged, their moult score recorded and released on site. If they were not already ringed, the birds were ringed to avoid re-sampling of the same bird. The samples were refrigerated as soon as possible and then sent to the Central Animal Pathology Laboratory, Keele or the Veterinary Laboratories Agency, Shrewsbury for analysis.

In view of the high lead levels in Mute Swans at certain sites, it was thought to be worth looking at other species of waterfowl in order to establish whether they carry similarly elevated lead levels. At Stratford in July 2001, 21 Canada Geese *Branta canadensis* and 20 Mallard *Anas platyrhynchos* were sampled together with the Mute Swans.

Results

Rescued birds

Results are summarised in Table 1. Slightly over 60% of all the birds sampled had blood lead levels in excess of 1.21 μmol/l, with the lowest proportion at RSPCA West Hatch (55.6%) and almost identical proportions in the areas serviced by Wychbold Swan Rescue in Worcester and RSPCA Stapeley Grange in Cheshire (76.1% and 75.6% respectively).

Tables 2 and 3 show the results for the two RSPCA centres, broken down by month. For Stapeley Grange, the 341 birds had mean blood levels of 5.66 μmol/l or almost five times the 1.21 μmol/l threshold. Indeed, almost 75% of all swans sampled exceeded the threshold. For West Hatch, despite blood sampling being targeted at swans with suspected lead poisoning in the first two to three years (1994–1996), there is no evidence of a change in the proportion of birds with lead poisoning over time. The 596 birds had mean blood lead levels of 3.94 μmol/l.

Other studies have shown a peak in rescues due to tackle injuries in the summer, put down to the increased amount of angling in evenings, the school holidays and the large increase of naïve cygnets (Perrins *et al.*, 2002). There is however, no clear trend for there to be elevated lead levels in the birds in the summer.

Flock samples

Results are summarised in Table 4; the table groups together the "river sites" and the lakes that were expected to be relatively leaded, followed by the relatively unleaded ("clean") sites. There are large and statistically significant differences between the median blood lead levels in different sites and some birds had very high levels. The following are the most important points to note:

Rivers.

1) The Warwickshire Avon and Severn. All Stratford and Bewdley birds exceeded the 1.21 μmol/l threshold.
2) The Thames. All Hampton and Reading birds and 31/35 (88.6%) of the Windsor birds exceeded the 1.21 μmol/l threshold. However, seven birds from Windsor and another seven from Reading, although over 1.21 μmol/l were below 1.93 μmol/l.
3) The Trent. Although the sample size is small, 5/6 (83%) of the Nottingham birds had blood lead levels above the 1.21 μmol/l threshold level.

Lakes.

4) 2/9 (22.2%) of the Colwick birds had blood lead levels above the 1.21 μmol/l level whilst 17/

Table 1. *Blood lead levels in Mute Swans examined by RSPCA and Wychbold Swan Rescue*

Centre	Period	n	Blood lead levels (μmol/l) Mean	Median	% > 1.21μmol/l
RSPCA Stapeley Grange	Sept 1998–Dec. 1999	341	5.66	2.00	75.6
RSPCA West Hatch	June 1994–Oct. 2001	596	3.94	1.4	55.6
Wychbold Swan Rescue	Dec. 1997–June 2000	339	7.16	2.66	76.1

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Table 2. *Mean and median blood lead levels (μmol/l) in Mute Swans taken to RSPCA West Hatch, June 1994 to October 2001*

	n	Mean	Median	Min	Max	% > 1.21 μmol/l
Jan	67	5.89	1.84	0.17	46.28	56.7
Feb	62	6.77	2.31	0.14	84.57	77.4
Mar	44	5.74	2.56	0.10	38.70	70.4
Apr	22	3.37	1.84	0.29	18.84	63.6
May	34	2.14	1.06	0.23	25.45	47.1
Jun	47	2.27	1.09	0.01	35.37	78.7
Jul	31	3.73	1.17	0.10	29.92	48.4
Aug	42	1.35	0.92	0.02	5.12	42.9
Sep	56	7.17	2.09	0.17	80.00	69.6
Oct	67	2.46	0.99	0.06	55.11	43.3
Nov	63	2.34	1.26	0.01	23.77	90.5
Dec	61	3.52	1.68	0.10	26.99	57.4
TOTAL	596	3.94	1.40	0.01	84.57	55.6

Table 3. *Mean and median blood lead levels (μmol/l) in Mute Swans taken to RSPCA Stapeley Grange September1998 to December 1999*

	n	Mean	Median	Min	Max	% > 1.21 μmol/l
Jan	26	3.88	2.44	0.25	14.26	80.8
Feb	22	7.81	3.72	0.64	27.19	86.4
Mar	12	1.40	1.11	0.40	5.12	41.7
Apr	16	5.17	2.90	0.20	16.49	93.8
May	19	7.42	2.15	0.23	52.54	78.9
Jun	25	5.04	1.92	0.49	38.00	80.0
Jul	12	2.08	1.91	0.35	6.86	66.7
Aug	23	4.73	2.36	0.45	26.34	87.0
Sep	38	10.12	2.28	0.55	111.20	76.3
Oct	64	6.22	1.69	0.22	122.56	67.2
Nov	42	2.26	1.61	0.16	7.90	69.0
Dec	42	6.68	1.83	0.01	49.80	81.0
TOTAL	341	5.66	2.00	0.01	122.56	75.7

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18 (94.4%) of the Southport birds were above the threshold.

Clean sites.

5) The birds in the three "clean" sites had relatively low lead levels as was expected. At Christchurch only 2/15 (13.5%) birds had levels in excess of 1.21 μmol/l (and they were only 1.35 and 1.50 μmol/l). Of the Slimbridge sample, 20/27 (74%) had blood lead levels below or equal to 1.21 μmol/l and the highest of the others was only 3.24 μmol/l. At Abbotsbury, only 3/35 (8.6%) of the total of birds sampled on the two occasions) exceeded the 1.21 μmol/l level.

Comparison of lead levels in swans with those of other species

Table 5 shows the blood lead levels in the three species Mute Swan, Canada Goose and Mallard which were sampled at the same time in Stratford in July 2001. Canada Geese had the lowest levels and Mute Swans the highest with Mallard intermediate. The differences in the mean lead levels in the blood of the three species are statistically significant (Table 5), indicating that, although they live in the same place, they are differently susceptible to the lead in the local environment.

Comparison with earlier studies

Mute Swans on the Thames were examined for lead poisoning from the late 1970's until 1991 (Lievesley, 1997). Most of these samples were taken during the summer months (July–September) allowing comparison with the measurements reported in this study. Lievesley (1997) summarises the results of blood lead measurements taken (from swans) in the Hampton, Windsor and Reading areas during the years (1980–1991). The median blood lead levels dropped in the years following the bans; by 1991 they were approximately half the levels in 1980, showing that the reduction in available lead did lead to a reduction in blood lead levels. Unfortunately, the 2000/01 data bears a remarkable similarity to the 1989/91 data, showing that the decline in lead levels observed at these sites

Table 4. *Mean, median and range of blood lead levels (μmol/l) in Mute Swans from different flocks and the percentage that exceeded 1.21 μmol/l*

	n	Mean	Median	Min	Max	% > 1.21μmol/l
Stratford 2000	20	13.1	3.1	1.9	145.4	100
Stratford 2001	21	3.3	2.5	1.0	19.0	100
Bewdley	10	16.4	10.0	2.6	52.6	100
Hampton	21	12.8	4.3	2.3	78.7	100
Windsor 2000	20	3.8	3.2	0.9	9.7	85
Windsor Feb 2001	15	4.7	3.2	1.0	19.0	93
Reading	20	2.9	2.2	1.4	7.2	100
Nottingham	6	6.1	4.7	0.6	16.9	83
Southport	18	5.8	5.2	0.9	10.1	94
Colwick Park	9	0.8	0.7	0.2	1.9	22
Christchurch	15	0.9	0.7	0.3	1.5	13
Abbotsbury 2000	15	0.5	0.4	0.1	2.3	7
Abbotsbury 2001	21	0.7	0.6	0.2	2.0	9
Slimbridge	27	1.2	1.1	0.3	3.2	25

Table 5. *Mean, median and ranges of blood lead levels (μmol/l) in three species of waterfowl at Stratford, July 2001*

	n	Mean[a]	Median	Min	Max	% > 1.21 μmol/l
Mute Swan	21	3.36	2.53	1.36	15.99	100
Mallard	20	1.34	1.27	1.27	4.03	50
Canada Goose	21	0.84	0.69	0.21	3.11	9

a: means are statistically significantly different: Swan to Mallard.
$T = 2.84$, $P = 0.01$, Mallard to Canada Goose $T = -2.18$, $P = 0.036$.

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during the late 1980's has not continued during the following decade.

Forty-one birds at Abbotsbury were sampled in 1984 (Hunt, personal communication) and had low lead levels, similar to those taken for this study: 13/41 (31.7%) of swans exceeded 1.21 mol/l, but only one exceeded 1.93 mol/l and that was only 1.98 mol/l.

Discussion

Lead is a highly malleable and very dense metal. These two properties have favoured its use both as fishing weights and as gunshot. The popular sports of fishing and shooting have resulted, over the years, in the release of an enormous quantity of lead into the environment. Whilst the problem may not be as significant as it is reported to be on the Continent (Duranel, 1999; Pain, 1991) where hunting, especially, is a very popular sport, a large quantity of lead has been deposited in our waterways.

We have used here the level of 1.21 μmol/l in the blood as that above which the bird may be said to have an elevated lead levels. The proportion of swans that are "over the limit" is clearly dependent on the threshold used. Is this threshold justifiable? Different workers have used different threshold levels; the threshold of 1.93 μmol/l (40 μg/100 mls, 0.40 ppm) has been used by Buck *et al.* (1976) and Sears and Hunt (1992). Regardless of whether such a threshold denotes real sickness, the use of a level of 1.21 μmol/l seems ecologically reasonable, in that the sites thought likely to be to be "clean" (Slimbridge, Christchurch, Abbotsbury) have swans which are largely below this level whereas areas known to have had high lead levels in the past (Stratford, Nottingham, the Lower Thames) have higher proportions of birds above the threshold.

The values reported here in the two RSPCA samples are necessarily biased towards sick and injured birds. However, almost all swans admitted to the RSPCA hospitals are sampled unless they are (i) considered to be healthy, and therefore ready for an immediate return to the wild, or (ii) euthanased on arrival. If samples were taken purely where lead poisoning was suspected then there would be an obvious bias towards high lead levels, but this is not the case. In practice, the population sampled consists of birds from a very wide range of "clean" and "unclean" sites and many are admitted because of injuries rather than sickness. Hence although the results reported here are biased towards sick and injured birds, it is a cause for concern that such a high proportion of birds admitted have elevated blood lead levels.

The purpose of the second part of this study was to explore the blood lead levels in a variety of UK flocks. There is a significant difference between the

lead levels found in swans from "clean" and "unclean" areas. The high proportion of birds showing elevated lead levels during the course of this project, points to the existence of a readily available source of lead in the environment. There are a number of (not mutually exclusive) sources for this lead.

i. The birds are finding long-lost leads. It had always been realised that banning the use of lead fishing weights would not solve the problem of lead poisoning immediately since there are large quantities of (long-lost) lead weights throughout the waterways system. Such lead could include shooting shot but nowadays most areas frequented by swans are not shot over and this is particularly true of the places surveyed in this report. The bans on use will have significantly reduced any further contamination of the environment with lead but the pre-legislation activities of fishermen and hunters have left a legacy of lead in UK waterways. Some of this lead is likely to be available for ingestion by swans in their search for grit.

ii. The swans are picking up illegal lead, currently in use. In a recent survey for the Environment Agency, Perrins *et al.* (2002) examined fishing tackle removed from rescued swans. 249 out of the 837 rigs contained at least one weight. Of these, 34 (13.7%) included 96 illegal lead weights. In contrast, a survey of the weights in use by 60 anglers, at Stratford in June 2000, showed that only one (1.7%) was using illegal weights (A. Taylor pers. comm.).

iii. The swans are picking up legal "dust" shot (sizes 8 and smaller). It is legal to use the very small lead weights, or "dust shot", because at the time when the bans were introduced it was thought too difficult to make substitutes from alternative materials. The largest permissible lead split-shot (No. 8) weighs 0.06 grams. If one assumes that when a swan ingests a lead weight, all the lead is absorbed into the blood stream, then a single No 8 weight would result in a blood lead level of about 29 μmol/l (6 ppm) in a 10 kg swan. Smaller swans (juveniles and non-breeding birds average 6–9 kg) would develop higher levels and ducks and cygnets even more (cygnets start life at about 250 g). In line with this, Bellrose (1959) reported an increase in mortality in Mallard of 9% in males and 22% in females following the ingestion of a single No 6 weight. An argument against dust-shot being the sole or even the major source of the lead is to be found in Tables 2 and 3. In earlier studies (e.g. Sears & Hunt, 1991) there was a reduction in lead-poisoning during the coarse fishing close season, indicating the recently lost lead were an important component in the situation. The RSPCA data in Tables 2 and 3 do not show this pattern.

iv. The swans are obtaining particulate lead from some unidentified source. The possibility that the lead originates from some other source has been considered in the past, but none has been identified. The most frequently suggested alternative source, lead in petrol or diesel is unlikely: firstly, there is no lead in diesel; secondly, lead has been withdrawn from petrol following the recognition that it posed a serious environmental health hazard. Today, only a small proportion of petrol contains lead.

Lead from petrol is known to contaminate vegetation close to roads. Geese graze grass on the river banks more than swans and, prior to the withdrawal of lead in petrol, are known to have acquired elevated lead levels from grazing grass near roads (Pain, 1987). In this study the Canada Geese sampled at Stratford showed significantly lower lead levels than swans sampled at the same location. This would suggest that the high lead levels in the Stratford swans cannot be explained by contaminated grazing.

Other sources of lead, reported as causing poisoning in a range of animals include lead paint, lead acid batteries, grease or used motor oil, curtain weights, linoleum, putty and plaster. Whilst these could all potentially contaminate the environment, it is unlikely that they are ingested by swans and other waterfowl.

It is equally unlikely that the lead comes from birds drinking the water — if this was badly contaminated, then the lead would also be found in humans because all the rivers surveyed are used for drinking water. In conclusion, the existence of some source of lead other than fishing weights would appear unlikely. Whatever it is, the source must be more easily available to Mute Swans than to Mallard or Canada Geese.

Individual swans are commonly presented to rehabilitation centres with acute lead poisoning. In order for this to happen they must expose themselves to a source of lead but why are all swans from the same area not similarly affected? This could just be down to chance—the unfortunate consumption of a number of lead weights. It could, however, be explained by a number of other factors:

i. swan movements. Swans moving into an area with high lead levels, particularly during the summer when water levels may be lower, may pick up enough lead to cause chronic health problems, only showing signs of toxicity at a later date when they have moved out of the area. It is therefore important to identify flocks of birds that do not move in and out of the area in any significant way — even a

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small number of new arrivals from high lead areas could affect the mean lead levels. This survey has tried to minimise this effect by studying birds from flocks during, or just after, moult and by sampling stable populations such as that at Abbotsbury.

Another problem is that the time taken between ingestion of lead shot and the development of signs of toxicity has not been established. Softer grades of lead, such as angling weights, are likely to be more easily broken down in the gizzard and made available for absorption than harder ones, such as shooting shot. Other factors, such as the composition of grit and diet, may also affect the rate of break down of lead shot, its absorption from the digestive tract, and the rate of development of symptoms. If the lead is only broken down slowly, it may be possible for the swan to move around a lot before developing symptoms.

ii. swan behaviour. Swans have been reported to exhibit lead pica, in much the same way that man and cattle do. Lead pica is the term used to describe the desire to consume more lead once poisoning has occurred, leading the subject to actively seek out further sources. Birds recovering from acute poisoning have been known to ingest large quantities of lead shot in a short period of time, suggesting that this is not accidental (S. Cooke personal communication).

The metabolism of lead in swans and the means by which it causes the observed clinical signs are not fully understood. It seems likely however, that the more obvious clinical signs of weakness (e.g. neck kink), weight loss, diarrhoea and immune suppression are related to chronic lead poisoning — the absorption or release of small quantities of lead into the blood stream over a relatively long period. Some of this lead will be removed from the blood and stored in tissue such as bone and liver, both dynamic systems which can take up lead rapidly but also release stored lead back into circulation. For example, as chronic lead poisoning occurs, hepatocytes atrophy (Wobeser, 1997) and release of stored lead may add to the circulating lead level. Acute lead poisoning with proventricular dilation and impaction and death results from the rapid absorption of massive levels of lead from easily assimilated sources. These factors make correlation between circulating lead and the severity of the observed signs unreliable.

iii. individual swans tolerance of lead. Certain individual birds show little or no sign of lead toxicity despite blood lead levels greatly in excess of the threshold. This suggests that some birds are less susceptible to lead poisoning and less likely to develop overt signs of acute toxicity, but does not preclude the possibility of significant long term health effects.

O'Halloran *et al.* (1988) showed that birds flying into wires may have higher than average lead levels, suggesting some reduction in response speed in birds with elevated blood lead levels. This may also apply in other accidents leading to a bias towards high lead levels in studies of rescued birds. This effect was not found by Perrins & Sears (1981), but it might be difficult to show if birds that were carrying high lead levels were unwilling or unable to fly.

A major problem with all studies of toxicity, including lead poisoning in swans, is that there is no clear point at which one can say an animal is healthy or is sick. As discussed above, some swans with relatively low levels of lead in their blood exhibit severe signs of lead poisoning when others with higher blood lead levels seem unaffected. Some swans with very high levels survive, the levels gradually decreasing with time.

Because of this large individual variation, recognition of the condition remains a problem. Much emphasis has been placed on the birds having "kinked" necks (due to impacted gizzards and a weakening of the neck muscles), but this only applies to certain birds with very high lead levels. Birds with lower, but still elevated levels may appear quite healthy or be quite sick. Only a blood assay will determine whether such birds have elevated lead levels or are ill for another reason.

In terms of treatment, birds with levels just above 1.21μmol/l are not normally held to be in need of treatment, other than isolation from the source where possible. Routh (2000) recommends that treatment should be initiated for birds whose blood lead levels exceed 2μmol/l (0.41 ppm) if there is evidence that they may have more lead in the gizzard (i.e where birds show radio-opaque substances on X-ray), but not until 5μmol/l (1.04 ppm.) in birds where there is no such evidence.

The higher median levels at "unclean sites" compared to "clean sites" raises concerns that these swan populations may be exposed to chronic toxicity whilst the high individual levels points to the very real threat of acute lead toxicity. Despite changes in legislation to ban the use of most lead fishing weights, lead poisoning remains a significant cause of morbidity (and mortality) in the UK swan population.

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RÉSUMÉ

Enquête sur les taux de plomb dans le sang chez le cygne tuberculé (*Cygnus olor*)

Depuis l'interdiction de l'utilisation du plomb pour la pêche à la ligne, l'incidence des cas d'intoxication au plomb chez le cygne tuberculé a commencé à diminuer et la population de cygne a commencé à augmenter. Cependant, les études sur les taux de plomb dans le sang chez les cygnes rescapés montrent qu'une forte proportion d'oiseaux présentent des taux en excès de 1,21 µmol/l. Vu que les cygnes rescapés, l'étaient pour des raisons différentes qui certainement ont biaisé l'échantillon, une enquête a été menée chez des oiseaux apparemment en bonne santé vivant en troupeaux durant l'été. Cette enquête a montré également un fort pourcentage d'oiseaux dans la plupart des troupeaux échantillonnés présentant des taux de plomb dans le sang qui excédaient 1,21 µmol/l. Aucune source de plomb n'a été identifiée autre que celle utilisée pour la pêche ; ces plombs doivent être anciens et perdus depuis longtemps ou actuels mais utilisés illégalement, ou des plombs de chasse qui sont encore autorisés.

Bien que beaucoup des oiseaux échantillonnés présentent du plomb qui n'est probablement pas nuisible, d'autres sont sérieusement affectés. A l'exception des cas les plus sévères, il n'est pas possible de reconnaître les oiseaux avec des taux élevés en plomb sans faire une analyse à partir du sang.

ZUSAMMENFASSUNG

Eine Übersicht zu Bleigehalten im Blut von Höckerschwänen (*Cygnus olor*) Nach dem Verbot der Verwendung der meisten bleihaltigen Angelgewichte begann das Vorkommen von Bleivergiftungsfällen bei Höckerschwänen zu sinken und die Population begann wieder zuzunehmen. Untersuchungen von Bleigehalten im Blut von geretteten Schwänen zeigten jedoch weiterhin einen hohen Anteil von Vögeln mit Gehalten von mehr als 1,21 mol/l. Da die Proben aus geretteten Schwänen, auch wenn sie aus vielen verschiedenen Gründen gerettet worden waren, ein verzerrtes Bild liefern könnten, wurden Untersuchungen bei offensichtlich gesunden Vögeln durchgeführt, die im Sommer in Gruppen zusammen leben. Auch diese Untersuchungen zeigten, dass in den meisten der untersuchten Gruppen ein hoher Prozentsatz der Vögel Bleigehalte von mehr als 1,21 mol/l Blut aufwiesen. Es konnte für dieses Blei keine andere Quelle identifiziert werden als bleihaltige Angelgewichte; diese mögen vor langer Zeit verloren worden sein oder es sind neuere, aber illegal benutzte Gewichte oder verstreute Schrotkugeln, die nach wie vor legal angewendet werden dürfen. Obwohl viele der untersuchten Vögel Bleigehalte aufzeigten, die wahrscheinlich nicht schädlich sind, sind andere ernsthaft belastet. Außer in den hochgradigsten Fällen ist es nicht möglich, die Vögel mit erhöhten Bleigehalten ohne eine Blutprobenentnahme für die Untersuchung zu erkennen.

RESUMEN

Estudio de los niveles sanguíneos de plomo en cisnes mudos (*Cygnus olor*)

Tras la prohibición del uso de la mayoría de pesos de plomo en la pesca, la incidencia de los casos de intoxicación por plomo en cisnes mudos ha empezado a disminuir y la población ha empezado a aumentar. Aun así, el examen de los niveles sanguíneos de plomo en cisnes rescatados continúa mostrando que una elevada proporción de estas aves presentan niveles que exceden los 1.21 µmol/l. Como los cisnes rescatados, aunque lo son por diferentes motivos, podrían representar una muestra sesgada, se realizó un estudio de aves aparentemente sanas que se encontraban en diferentes grupos durante la época de verano. Un alto porcentaje de estas aves en la mayoría de grupos examinados también mostró niveles que excedían los 1.21 µmol/l. No se ha podido identificar otra fuente del plomo que no sea la de los pesos de plomo que se utilizan en la pesca; puede tratarse de plomos perdidos desde hace tiempo, pesos nuevos pero ilegales o bien "polvo de proyectiles" cuyo uso aún es legal.Aunque la mayoría de aves estudiadas presentan una carga de plomo que probablemente no es dañina, otras se encuentran seriamente afectadas. Excepto en los casos más graves, no es posible identificar las aves que presentan niveles de plomo elevados sin sacar una muestra de sangre para realizar el estudio.

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