RESULTS OF AN INVESTIGATION INTO THE INCIDENCE OF INGESTED LEAD SHOT AND ELEVATED BLOOD LEAD LEVELS IN MALLARD AND GREY DUCK POPULATIONS IN THE BAY OF PLENTY AND EAST COAST REGIONS OF THE NORTH ISLAND

Andy Garrick
Fish & Game New Zealand
Private Bag 3010
Rotorua

May 2000

TABLE OF CONTENTS

.

FIGURES

TABLES

Abstract

During the summer of 1998/99, blood samples were collected from 162 wild mallards and grey ducks randomly selected from a number of locations within the Bay of Plenty and East Coast regions of the North Island. Between 15.4% and 18.5% of these birds were found to have elevated (≥ 0.2ppm) blood lead levels. Incidences varied from 2% at one location to 40% at another. During the 1999 game season, 458 mallard and grey duck gizzards were obtained from hunters from the same regional locations. 8.95% of this sample contained lead shot considered to have been ingested. Again incidence was variable, ranging from 2.3% to 14.1% across sites. No differences were detected in ingestion rates between species or sexes, but blood lead analyses suggested that males may have been more inclined to ingest shot during summer than females, and that adults had a higher ingestion rate than juveniles. Insufficient information is available to estimate, with any real degree of certainty, annual mortality or the extent to which mallard and grey duck populations are sub-lethally affected as a consequence of lead shot being ingested. However, the incidences of ingested shot and elevated blood lead levels observed in this study suggest mortality rates and the numbers of birds sub-lethally affected could be disconcertingly high at some locations in some years.

1. Introduction

In October 1998, at the request of the Minister of Conservation, a working party was convened to advise on options which would reduce avoidable contamination of the environment by lead shot derived from shotgun use. One of the party's terms of reference was to encourage and co-ordinate any new research which might assist the education of hunters and managers about the effects of lead shot. An early outcome of the working party's deliberations was the identification of the need for an investigation(s) into the incidence of ingested lead shot and/or elevated lead levels in *New Zealand's* waterfowl populations. The investigation reported here was designed with two objectives in mind, these being to gain an insight into:

i) the extent of lead toxicosis in some of the waterfowl populations of the Eastern Region of Fish & Game New Zealand; and

ii) the costs and logistics of investigating the incidence of ingested lead shot in harvested NZ waterfowl populations using two approaches widely used overseas.

2. Methods

2.1 Blood lead levels

During the course of Eastern Region's mallard and grey duck banding programme in February and March 1999, blood samples were collected from 162 birds at six trap sites as shown in Table 1. Sampling comprised a randomised stratified design in which at least 50 birds were randomly selected from each of three regional locations:

the Kaituna/Maketu Plains, Aniwhenua/Galatea, and Gisborne/Wairoa (see Figure 1). Between 1.5 and 2.5mls of blood was collected from each bird via a small incision made in the brachial vein with a scalpel. Each sample was collected directly into a heparinised 2ml EDTA vial and placed into cold storage until delivery to a laboratory for analysis. Initially, samples (ex Gisborne and Aniwhenua) were processed by the Ruakura Animal Health Laboratory in Hamilton using a modified version of the colorimetric determination method described by Baxter and Allcroft (1950). This approach enables lead to be detected to levels of +/- 0.05mg/l (Mariette Komene *pers comm*). Interpretation of the resultant analyses indicated greater accuracy was desirable so the remaining 51 samples were despatched to the Institute of Environmental Science & Research in Wellington where they were diluted then analysed using an ICPM spectrophotometer. With this technique lead can be detected to levels of +/- 0.02mg/l (Sharon van Soest *pers comm*).

Sigma Stat Z-tests for comparison of proportions were used to investigate whether observed incidences of elevated blood lead levels differed significantly between age, sex and species groupings.

<u>Figure 1.</u> Eastern Region blood sampling locations.

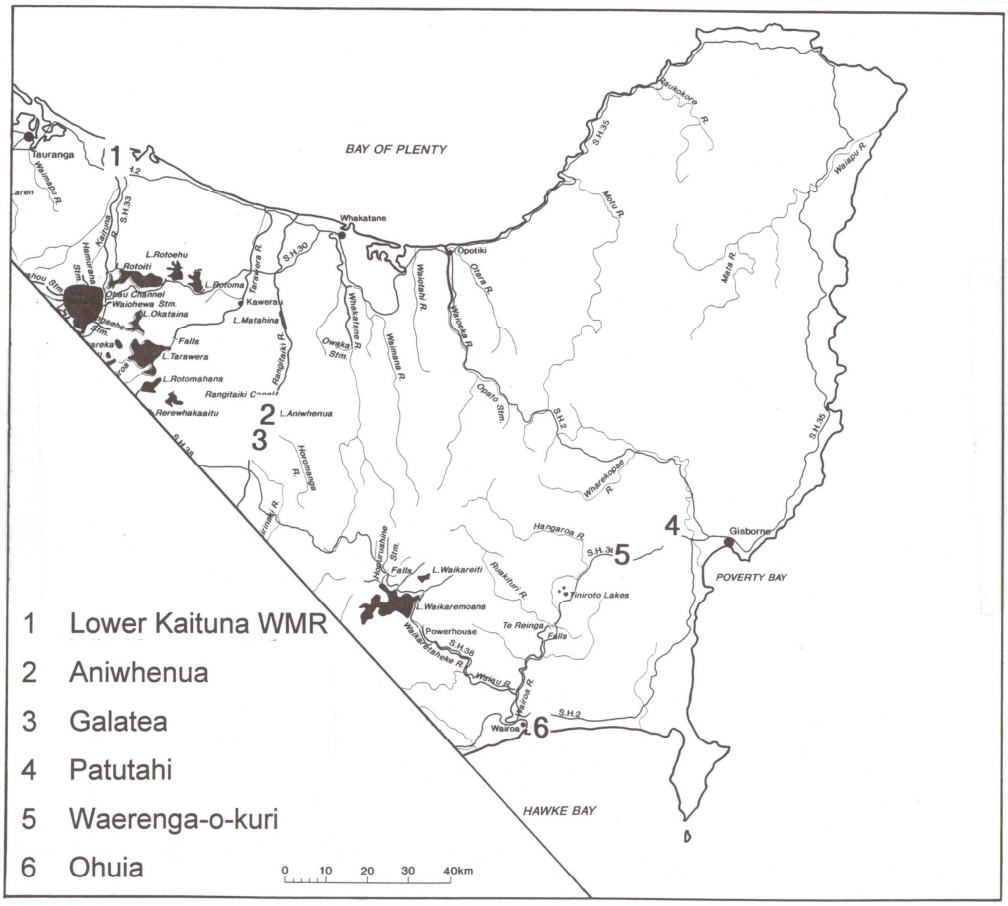


Table 1. Trap sites from which blood samples were obtained.

		Mallards[1]	Grey ducks[1]	**Totals**	
Coastal Bay of Plenty	Lower Kaituna WMR	42	9	51	**51**
Aniwhenua/Galatea	Aniwhenua	36	7	43	**50**
	Galatea	6	1	7	
Gisborne	Patutahi	25	0	25	**61**
	Waerenga-o-kuri	5	6	11	
Wairoa	Ohuia	20	5	25	
All locations		**134**	**28**		**162**

[1] Phenotypically obvious hybrids were categorised as either mallards or grey ducks on the basis of their predominant appearance.

2.2 Examination of gizzard contents

During the game season, May-July 1999, 458 mallard and grey duck gizzards were obtained from waterfowl harvested by hunters in essentially the same regional locations from which blood samples were collected the previous summer. Details of the sampling process, which was again set up to be of a randomised stratified nature, plus the instructions provided to hunters, are given in Appendix 1. The locations and numbers of samples obtained at each are shown in Table 2.

Table 2. Locations from which gizzard samples were obtained.

	Mallards[2]	Grey ducks[2]	Unidentified	**Total**
Coastal Bay of Plenty[1]	167	17	4	**188**
Aniwhenua/Galatea	94	30	4	**128**
Gisborne	72	27	-	**99**
Wairoa	38	5	**-**	**43**
All locations	**371**	**79**	**8**	**458**

[1] Principally Kaituna and Maketu Plains.
[2] Phenotypically obvious hybrids were categorised as either mallards or grey ducks on the basis of their predominant appearance.

Eight paradise shelduck and one shoveler gizzard supplied incidentally were also examined.

Subsequent processing involved opening each gizzard and flushing its contents into a 250mm diameter bowl. These contents were then diluted with water and the less dense material, principally food remnants, decanted off with the cycle being repeated until such time as clean grit, and sometimes larger seeds, was all that remained. The residual material was then oven dried and packaged into a labelled 50 x 130mm zip lock plastic bag. The gizzard from which the contents were derived was then inspected carefully for perforations or any other indication that any pellets found

might have been shot in as opposed to having been ingested. If the gizzard lining was heavily discoloured or sloughing, this too was recorded.

The presence of lead shot in gizzards was determined by analysis of x-ray radiographs of contents in accordance with the approach described by Montalbano and Hines (1978). Radiography was performed with an Atomscope 903 Type B-85 x-ray machine set at 50kV/35mA and an exposure of 0.08 seconds. Positive and questionable signatures were reshot at an exposure of 0.35 seconds to minimise background and ensure any false or doubtful positives detected in the first round were not incorporated into the final analysis. Visual examination under microscope of the residual positives was then undertaken to differentiate between ingested and embedded shot ie shot in to the lumen, this determination being aided by the notes previously taken on whether or not pellet entry wounds were apparent in gizzard linings and/or the appearance of the gizzard. Similar criteria to those described by Anderson and Havera (1989) were used to decide whether pellets had been ingested, or shot in.

Sigma Stat z-tests were again used for all pairwise comparisons.

3. Results

Appendix 2 gives details of the costs and logistics associated with investigating the incidence of ingested lead shot in mallard and grey duck populations in *this* study [cf objective ii)]. Other investigations may require more or less depending on circumstances.

3.1 Blood lead levels

Table 3 provides a summary firstly, of the percentage of samples demonstrating elevated[1] lead levels, and secondly, the percentage of samples with levels nominally deemed to be toxic[2] (at the time of sampling) within each of the sub-regional locations.

Table 3. Percent incidence of elevated lead levels in blood.

Sub-region	Site	*N*	"Elevated" Pb level[1] (n)	Toxic" Pb level[2]	**Total % elevated**
Coastal Bay of Plenty	Lower Kaituna WMR	*51*	15.7 *(n=8)*	9.8 *(n=5)*	**15.7** *(n=8)*
Aniwhenua/Galatea	Aniwhenua	*43*	2.0 *(1)*	2.0 *(1)*	**2.0** *(n=1)*
	Galatea	*7*	0	0	
Gisborne	Patutahi	*25*	16-32 *(4-8)*	4.0 *(1)*	**16.7-30.6** *(n=6-11)*
	Waerenga-o-kuri	*11*	18.2-27.3 *(2-3)*	9.1 *(1)*	
Wairoa	Ohuia	*25*	40.0 *(10)*	0-12.0 *(0-3)*	**40.0** *(n=10)*
All locations		*162*	15.4-18.5 *(25-30)*	4.9-6.8 *(8-11)*	**15.4-18.5** *(n=25-30)*

[1] Blood lead levels ≥ 0.2 ppm.
[2] Blood lead levels ≥ 0.5 ppm.

Overall, between 15.4 and 18.5% of the 162 samples collected from the region had blood lead levels recognised internationally as being above normal or background levels. The imprecision of this estimate, along with that given for the Gisborne area, reflects the lesser accuracy of the laboratory technique used to analyse the samples from these areas compared to that used for the samples collected elsewhere.

No difference was apparent in the proportions of "mallards" (15.7-18.7%) versus "grey ducks" (14.3-17.9%) with elevated blood lead levels. Similarly, there was no statistically significant difference between the incidence of high blood lead levels in males (19-22%) and females (9.7-12.9%) at $\alpha = 0.05$, though this was not far from being the case in a comparison of the extreme values in each range (P=0.072).

In a comparison of juveniles (10.3%) versus adults (19.1-24.5%), a statistically significant difference was not apparent when comparing the incidence in juveniles with the lower value (19.1%) calculated for adults, but was detected in a comparison with the upper value (24.5%) given in the range (P=0.036).

3.2 Examination of gizzard contents

Table 4 indicates the proportions of mallard and grey duck gizzards containing ingested lead shot within each of the sub-regional locations.

Table 4. Percentage of gizzards containing ingested lead shot.

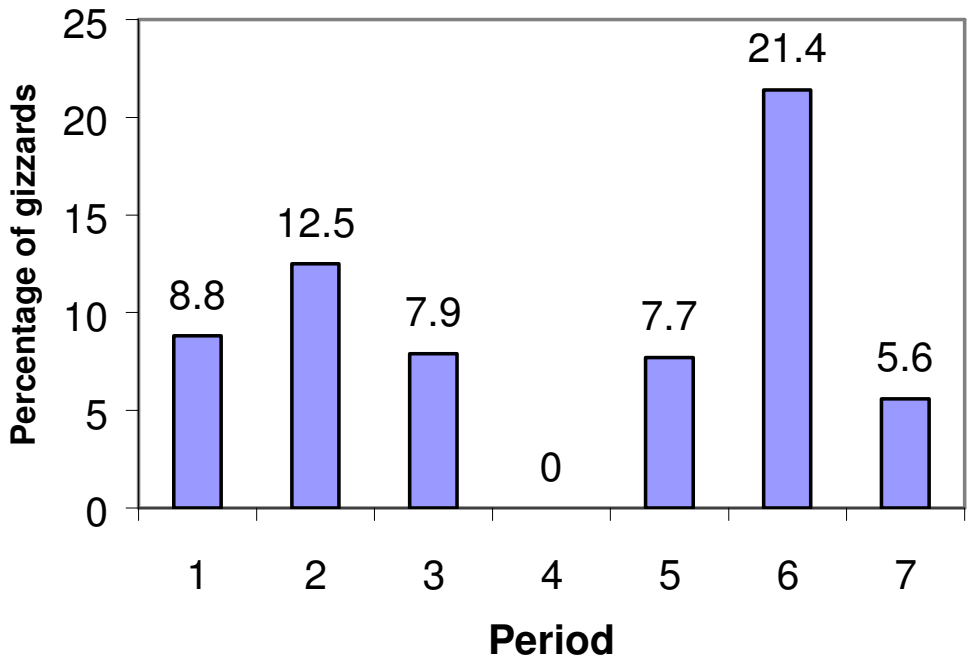
Sub-region	Site	*N*	# gizzards containing ingested[1] shot	**Total %**
Coastal Bay of Plenty	Benner Road	*108*	*11*	**11.7**
	Lower Kaituna WMR	*56*	*10*	
	Other sites	*24*	*1*	
Aniwhenua/Galatea	Aniwhenua	*96*	*3*	**3.1**
	Terpstra's & Horomanga	*32*	*1*	
Gisborne	Waerenga-o-kuri	*24*	*4*	**14.1**
	Tangihanga	*23*	*3*	
	Patutahi	*21*	*1*	
	Totangi Road	*16*	*0*	
	Waipaoa R. mouth	*15*	*6*	
Wairoa	Potutu Station	*26*	*1*	**2.3**
	Other sites	*17*	*0*	
All locations		***458***	*41*	**8.95**

[1] Twenty-two, or 4.8% of the 458 samples contained lead shot which was categorised as having been shot-in, and a further 8 or 1.7% could not be classified as either ingested or embedded.

Just under 9% of the 458 gizzards examined contained lead shot deemed to have been ingested as opposed to having been shot in. There was no significant difference in the incidence of ingested shot between "mallards" (9.4%) and "grey ducks" (7.6%) at $\alpha = 0.05$, nor between the proportions observed in male mallards (9.7%) versus female mallards (12.5%).

Sixty-one per cent of the gizzards containing ingested shot and 62.2% of the gizzards sampled in total were obtained from Opening Weekend, the remainder from the rest of the season. Figure 2 shows the percentage of samples with ingested shot recorded during each week of the season.

Figure 2. Percentage of gizzards containing ingested lead shot during each week of the season.



Key to figure:

Period	Definition	Sample size
1	Opening Weekend	285
2	Rest of Week 1	56
3	Week 2	38
4	Week 3	0
5	Week 4	13
6	Week 5	14
7	Week 6	36

Some gizzards contained more than one pellet. Table 5 records the number of pellets or fragments of pellets observed in the 41 gizzards in which ingested lead was identified.

Table 5. Numbers of pellets recorded in gizzards.

# of pellets	% of gizzards (*n*)
1	70.7 (*29*)
2	14.6 (*6*)
3	2.4 (*1*)
4	2.4 (*1*)
fragments	9.8 (*4*)

Two of the eight paradise shelduck gizzards examined from Aniwhenua also contained ingested lead shot (one pellet each).

4. Discussion

4.1 Occurrence of lead poisoning in New Zealand

There have been no comprehensive investigations into the incidence or implications of lead poisoning on avifauna as a consequence of ingesting spent lead pellets in New Zealand. Three one-off studies have investigated the incidence of ingested shot in mallards and grey duck, and two of these have also included an examination of shoveler gizzards, but none have been particularly intensive or extensive. Ingestion of lead shot however, and in some instances mortality determined or presumed to have been due to lead poisoning, has been periodically reported for over sixty years. Falla, cited in Wisely and Miers (1956), noted the presence of lead pellets in the stomachs of knots collected from Lake Ellesmere in 1934, while Wisely and Miers *loc cit* recorded lead poisoning of black swan at Woodend Lagoon near Christchurch in 1951. Wisely and Miers noted also, that lead shot had been found in a number of dead mallards and grey ducks found at Lake Waikare, Huntly, and at the Wairau Bar in Blenheim.

Caithness (1974) recorded lead shot in the gizzards of 61 mallards, grey duck and black swan found dead or moribund during the period 1969-1974 in Pukepuke Lagoon and other shallow wetlands in coastal Manawatu. I also located lead shot in black swan (18 birds) and mallards (2 birds) found dead or in an impaired state at Pukepuke Lagoon between 1977 and 1979 (Garrick, 8 reports May 1977 - March 1979), in addition to observing other individuals of the same species which I suspected at the time to have been lead poisoned.

Using a combination of fluoroscopy and visual examination of gizzard contents, Bellford (1975) recorded pellets in 5.7% of 279 mallard and grey duck gizzards obtained from hunters in the central, Dunedin and Taieri regions of Otago during the 1975 game season. Two of 18 shoveler gizzards were also found to contain lead shot (three pellets in each).

The Press (1985), cited in Lobb *et al* (1997), and Bellingham (1991) reported cases of lead poisoning in Canada geese and black swans respectively, at Lake Ellesmere.

Dyer (1991), in the largest and most extensive sample collected to that point in time, recorded lead shot in 4.7% of 467 mallard/grey duck gizzards obtained during the 1990 game season in the Auckland/Waikato Fish and Game region. Incidence varied from 13.9% of 91 gizzards examined from one site to 2.7% over the remaining 376 samples, results indicating considerable geographic variability.

Lobb *et al* (1997) observed lead shot in the gizzards of two of 19 (10.5%) mallards and one of 18 (5.6%) shoveler shot at Lake Ellesmere during the 1996 game season. From a sample of 21 livers from these birds, elevated lead levels (≥ 2.0ppm) were detected in five (23.8%). The presence of lead shot in gizzards was determined by visual examination alone. Ten pellets were recorded in the shoveler gizzard.

The present study extends the known occurrence of lead poisoning in waterfowl to the Bay of Plenty and East Coast regions of the North Island, and provides further evidence for the likelihood that ingestion of lead shot by waterfowl is both a widespread and ongoing phenomenon in New Zealand. The results of the study indicate that the incidence of lead shot ingestion and hence lead poisoning can vary widely, at least spatially and probably temporally. Comparison of both blood lead level data and the percentages of gizzards containing lead shot in the Aniwhenua/Galatea area versus other parts of the region provides evidence of the former, while a comparison of the very high proportion of ducks with elevated blood lead levels obtained from Wairoa in summer (40%) versus the relatively low incidence of lead shot in gizzards recorded from the Wairoa area in winter (2.3%) is suggestive of the latter. While this seasonal variation may simply be an artifact of the sampling programme, there is considerable evidence elsewhere to demonstrate that season can have an important influence on shot ingestion rates, though seasonal patterns are not necessarily consistent (Pain 1992). In Europe most studies have shown a trend towards a decreased incidence of shot ingestion as the hunting season progresses, whereas in the USA, shot ingestion rates tend to increase as the hunting season advances. Bellrose (1959) concluded from his definitive study that most die-offs from lead poisoning occur in the USA during the late fall and early winter after the close of the hunting season. These continental differences can probably be attributed to changes in density and accessibility of deposited shot, changes in waterfowl distribution and habitat usage, and possible changes in species' seasonal "gritting" behaviours.

No clear cut trend in the incidence of ingested shot over time emerged during the hunting season in which this investigation was undertaken. In week five, 21.4% of the gizzards examined contained shot compared to 8.8% over the opening weekend of the season, but sample size in week 5 (as in weeks 4 and 6) was small and a significant difference was not detected.

In addition to seasonal variation it is apparent that incidences of lead poisoning can vary from year to year. My observations of lead poisoned waterfowl at Pukepuke Lagoon during the period 1977-79, and those of Caithness (1974), indicated that water levels were a critical factor there, Caithness noting that lead poisoning was not detected in 1970/71 when water levels were stable nor did it occur to any marked extent until levels had dropped about 30cm below "normal". Drier than normal conditions prevailed in the Eastern Region during the 1998/99 summer period prior to the collection of blood samples. In many parts of the region including the coastal Bay

of Plenty, Gisborne and Wairoa locations at which blood was obtained, it is conceivable that lead shot may have been more readily available to waterfowl than it might have been had the season been a wetter one. In the Aniwhenua/Galatea area however, the converse may have been true in that lead shot may have been less accessible than it would have been in a wet year. Andre Terpstra *pers comm.* advised that most of the shallow wetlands on farmland within the valley had dried up early in the summer forcing much of the local waterfowl population onto the deep and fast flowing Rangitaiki River or onto the muddy bottomed Lake Aniwhenua. At these sites shot may be less available to dabbling ducks than might be the case in the habitats occupied during "normal" seasons.

4.2 Interspecific differences

Given i) the habitats sampled, ii) the extent to which mallard and grey duck interbreed as recently indicated by Williams (1998), and iii), the classification, in this study, of a bird as either a grey duck or a mallard even though hybrid characteristics might have been apparent, it is not altogether surprising that differences were not detected in the proportions of "mallards" versus "grey ducks" with elevated blood lead levels or whose gizzards contained lead shot. Interspecific variation in the ingestion and uptake of lead can be large in waterfowl, and consistent differences have been demonstrated from a wide range of countries in accordance with species' feeding strategies (see Pain 1992). The highest incidence of shot ingestion is found in diving ducks followed by dabbling species, with the lowest incidence in grazing species. Pain (1992) calculated an average ingestion rate for hunter killed dabbling ducks from ten European countries of 8.9% which is coincidentally remarkably similar to the 8.95% recorded in this study. An average rate of 5.0% was reported for the USA while Scheuhammer and Norris (1995) recorded an average of 5.1% for Canada.

The susceptibility of species to lead toxicosis is not necessarily correlated with ingestion rates however, as food habits (amount of protein, calcium, and phosphorus ingested) have a major bearing on the effects of the lead ingested. Mallards for example, whose diets comprise corn or cereal grains, are more susceptible to lead poisoning than those feeding on more natural plant and animal foods (cf Sanderson and Irwin 1976, Finley *et al* 1976, Finley and Dieter 1978a, Chasko *et al* 1984). A number of studies have indicated that high protein and/or calcium diets can mitigate the effects of lead (cf Koranda *et al* 1979 and various others cited in Havera and Anderson (1999)). Wild mallards which have ingested lead shot have been found to consume more plant and animal matter than birds which have not, suggesting affected birds may modify their diets to alleviate the symptoms of lead poisoning (Havera and Anderson 1999).

The incidental discovery of lead shot in two gizzards from a small sample of paradise shelduck indicates that this grazing species will also ingest lead shot.

4.3 Differences associated with sex

Although statistically significant differences were not detected between males and females in either the blood sample or gizzard analyses, there was a suggestion that there may have been a higher incidence of elevated blood lead levels in males than in

females during the summer period when these samples were obtained. Caithness (1974) noted that 46 of 47 mallards (98%) found dead or dying with lead shot in their gizzards in the Manawatu were males. Caithness speculated that males may differ from females in their feeding habits or grit requirements during summer months. An alternative but perhaps less likely explanation, would be that lead poisoned mallard males may simply be more conspicuous than their female conspecifics similarly affected during this period, particularly if it coincided with the timing of the latter's main moult.

Overseas experience does not reveal any consistent differences in ingestion rates by the sexes. White and Stendell (1977) did not observe any differences between male and female mallards or black ducks, but did record higher rates in male pintails in comparison with their female counterparts. Bellrose (1959) noted a higher proportion of female mallards with ingested shot compared to males.

Consistent differences in the effects of lead shot ingestion have however, been documented between the sexes, a number of experiments demonstrating females to be more susceptible to lead poisoning than males, except during spring (Sanderson and Bellrose 1986). Finley and Dieter (1978b) attributed this increased resistance in spring to a higher metabolic rate and the mobilization of energy resources for egg laying. Jordan and Bellrose (1951) recorded spring as being the only season in which food consumption by females exceeded that of males. Rocke and Samuel (1991) noted that adult male mallards exposed to lead pellets in the spring appeared to have lower numbers of certain immunologic cells which could render them more susceptible to some infectious agents.

4.4 Differences associated with age

The higher incidence of elevated blood lead levels indicated in adults versus juveniles in this study is generally in accord with the findings of overseas investigations. Shealy *et al* (1982) cited in Sanderson and Bellrose (1986), found that lead shot ingestion occurred more frequently in adults than in juveniles in both mallards and pintails at Catahoula Lake though the reverse was true there for canvasbacks (Hohman *et al* 1990). Stendell *et al* (1979) also recorded higher concentrations of lead in adults and a higher proportion of adults with elevated lead levels amongst mallards and a number of other species.

Experiments comparing weight loss and survival in immature (up to seven months old) and adult mallards dosed with lead shot indicate that juveniles may be less sensitive than adults (Sanderson and Bellrose 1986). Sanderson and Bellrose suggested this could be due to relatively more lead being removed from the circulation and deposited along with calcium in the skeletons of the young maturing mallards.

4.5 Number of shot ingested

In addition to intact pellets which were observed in 37 gizzards in this study, fragments of shot were recorded in a further four. If the latter are excluded and

relative incidences recalculated, the resulting proportions of gizzards containing 1 or 2 pellets are in the same order of magnitude as those which have previously been recorded in the United States or New Zealand as shown in Table 6.

Table 6. Percentage of mallard gizzards containing a specific number of lead pellets, and maximum number of pellets recorded in a gizzard in other investigations.

# of pellets	% of gizzards				
	Bellrose (1959)	*Sanderson & Bellrose (1986)*	*Anderson & Havera (1989)*	*Dyer (1991)*	*This study*
1	65.3	63.0	75.8	63.6	78.3
2	16.7	13.6	13.6	9.1	16.2
≥3	18.6	23.4	10.6	27.3	5.4
max #	?	?	21 pellets	9 pellets	4 pellets

Of the mallard and grey duck gizzards examined by Bellford (1975) from Otago, 75.0% were recorded as containing one pellet only.

Bearing in mind that Caithness' data were not derived from a random sample of live birds, it is interesting to note that of the 50 mallard gizzards collected during the period 1969-1974, the number of shot visually detected ranged from 1-284 pellets per gizzard with an overall mean of 35 per gizzard (see Caithness 1974). This can be compared with Bellford (1975) in which the range varied from 1-4 pellets per gizzard with a mean of 1.9, Dyer (1991) in which the range was 1-9 pellets per gizzard with a mean of 2.6, and a range in this study of 1-4 with a mean of 1.3 per gizzard. The large number of pellets observed in some mallard gizzards in each of the four years reported in Caithness (1974), suggests there is very likely to be a proportion of birds which suffer acute lead poisoning as a consequence of ingesting a large number of pellets and, due to a rapid onset in seriously debilitating symptoms, are unavailable to hunters, and therefore not recorded in samples obtained from hunters.

4.6 Effects of ingested lead shot on individuals

Lead interferes with most biological systems of waterfowl, including the haematological, digestive, muscular, excretory, immunological, reproductive and nervous systems (cf Beyer *et al* 1998; Rocke and Samuel 1991; Hohman *et al* 1990; Sanderson *et al* 1981).

Acute poisoning usually follows the ingestion of a large number of shot (≥10) and birds die within several days of exposure with very little loss of body weight and few external signs of poisoning. More frequently waterfowl die of chronic lead poisoning 2 or 3 weeks after the ingestion of a smaller number of shot, often in a very emaciated condition (Scheuhammer and Norris 1986; Pain 1992).

Ingestion of only one lead shot can be all that is required to kill a bird (cf Finley and Dieter 1978a; Sanderson *et al* 1981; Pain and Rattner 1988) though Sanderson and Bellrose (1986) suggest that waterfowl that ingest only 1 or 2 shot more often live

than die. Ingestion of a single pellet can result however, in a wide range of sub-lethal effects including inhibition of enzymatic activity in blood, liver and brain (Dieter and Finley 1978), cerebellar (brain) damage as a result of the latter (Dieter and Finley 1979), reduced packed cell volume and haemoglobin in blood (Sanderson *et al* 1981), reduced organ and body mass (Sanderson and Bellrose 1986) and impaired behaviour (cf Bellrose 1959).

Blood lead levels in waterfowl of more than 0.2ppm are widely regarded as being elevated or above background (cf Friend 1985; Sanderson and Bellrose 1986; Locke and Thomas 1996), while levels equal to or exceeding 0.4, 0.5 and 0.6ppm are categorised as being "acute" (Pain 1992), "toxic" (Roscoe 1986; Sanderson and Bellrose 1986), or "compatible with clinical toxicosis" (Locke and Thomas *loc cit*) respectively.

Dieter and Finley (1979) recorded blood lead levels of about 1ppm in mallard ducks one month after they had been dosed with a single No. 4 lead pellet while Havera *et al* (1989) found blood lead levels averaged 13.97ppm (range 1.0-33.36) seven days after a similar treatment. Roscoe *et al* (1979) reported comparable results and Havera *et al* (1992) recorded median blood lead concentrations in the order of 3.7-4.6ppm, again one week after dosing. These studies indicate that the ingestion of a single pellet can elevate blood lead levels well beyond the thresholds at which sub-lethal effects and permanent damage are recognised as likely outcomes. While diet and other factors can reduce the uptake of lead and mitigate the effects of lead ingestion as previously discussed, the inference to be drawn in the context of the present study is that a substantial proportion of the birds recorded with one or more pellets in its gizzard is likely to have suffered some form of permanent damage as a consequence. Such impairment be it of a biochemical, physiological or behavioural nature can indirectly result in higher mortality rates than those of birds which have not ingested lead shot through an increased risk of starvation, predation and disease (cf Rocke and Samuel 1991; Sanderson and Bellrose 1986; Scheumhammer and Norris 1986). Furthermore, mallards which have ingested lead shot are more susceptible to being shot by hunters than birds which have not, perhaps because of muscular or nerve impairment or simply because they have become less wary. Bellrose (1959), cited in Sanderson and Bellrose (1986) found that mallards which had been experimentally dosed with one No. 6 lead shot were 1.5 times more likely to be shot than birds which had not been dosed, birds with two No. 6 pellets were 1.9 times more likely to be shot, and birds dosed with four pellets were 2.1 times more likely to fall to the gun than mallards which had not been exposed to lead. On average, Bellrose calculated that hunters were 1.65 times more likely to shoot birds suffering from lead poisoning than birds which were not (Pain 1992). Heitmeyer *et al* (1993) observed an even greater discrepancy, finding hunter killed mallards were 3.8 times more likely to contain ingested lead shot than researcher-collected mallards though this finding has been the subject of some debate (eg Scheuhammer and Norris 1995).

4.7 Implications for mallard and grey duck populations

Extrapolating from the overall percentage of gizzards containing ingested lead shot in this study, just under nine percent of the Eastern Region's mallards and grey duck were likely to have been affected to some degree by lead poisoning during the 1999 game season. It is important to appreciate however, that the incidence of ingested

lead pellets in gizzards has been shown to be a less sensitive indicator of the true extent of exposure to lead shot than measures of lead levels in blood (Anderson and Havera 1985). Typically the incidence of above background concentrations of lead in blood exceeds that determined from gizzard analyses. Anderson and Havera (1989) for example, recorded the former as being 6-10 times greater on average than the incidences recorded for ingested lead shot in a study which involved the examination of a large sample of waterfowl, mostly mallards, in Illinois.

In this study, blood lead levels were not measured during the period in which gizzards were collected so this comparison is not possible here. Blood lead levels recorded during the previous summer however, suggested an overall incidence of elevated lead levels in 15.4-18.5% of the mallard and grey duck populations sampled at that point in time.

While each of these parameters provides an insight into the proportion of mallard and grey ducks affected during the specific periods in which they were obtained, we can only speculate as to what incidences prevailed during other occasions during the year, or indeed over the year as a whole. Experimental studies by Jordan and Bellrose (1951), cited in Pain (1992), found that lead pellets on average, persist in the gizzard for 18-21 days with a maximum residency time of six weeks. Sanderson *et al* (1981) recorded an average of 26.7 days while Sanderson and Bellrose (1986) noted that most waterfowl with ingested shot contain only one pellet which disappears from the gizzard in about 20 days. Blood lead levels following the ingestion of a lead pellet(s) however, remain elevated for a longer period. Havera *et al* (1992) noted that blood lead levels in wild mallards dosed with a single No. 4 pellet remained elevated for eight weeks, while Roscoe *et al* (1979), cited in Havera *et al* (1992), found that 90% of a group of mallards dosed with lead shot had abnormal blood lead concentrations for a period of five weeks.

As a pellet remains in the gizzard for only 3-6 weeks after its ingestion, and blood lead levels remain elevated for only 5-8 weeks, the proportion of mallards and grey ducks that consume lead shot over the course of a year is likely to be considerably higher than the proportions of ducks found to have pellets in their gizzards or to have elevated blood lead levels at any one point in time.

As an example, if we extrapolate from figures obtained during this study and model worse case scenarios, we would have to conclude that virtually the entire Eastern Region mallard and grey duck population could be affected by lead poisoning each year. On the Opening Weekend of the 1999 game season, 8.8% of gizzards contained one or more lead shot. As previously discussed, birds that have consumed lead shot have been found to be 1.5-3.8 times more likely to be shot than birds which have not. If we apply Bellrose's widely accepted "average" factor of about 1.65 to "correct" for this inflated perspective, we can calculate that the actual proportion of the population containing lead shot during the period sampled would have been closer to 5.3%. Given an average gizzard retention time of three weeks this implies that 5.3% of the population consumed lead shot within the three weeks preceding, and that over the next three weeks we could expect a comparable number of ducks to consume shot, and so on. Over the course of a year there are 52 divided by 3 = approximately 17 three week periods in which up to 5.3% of the population could be ingesting lead

pellets. Multiplying 5.3 times 17 gives a potential annual lead poisoning incidence of just over 90% of the population.

Repeating this exercise using the blood lead level figures obtained during the summer of 1999 suggests (15.4-18.5) times 52 divided by (5-8) = 100-190% of the population could have been exposed to lead poisoning.

The underlying assumptions on which these estimates are based are extreme in so much as they do not recognise that many of the birds which ingest one or two lead shot are likely to survive and ingest shot again while a proportion of the population is unlikely to ever encounter let alone ingest a pellet. Furthermore it is highly improbable that the observed incidences of gizzards containing lead shot, and birds with elevated blood levels in 1999, were the same for each and every 3-5 week period during the year, or from this year to another. What the exercise demonstrates however, is that the proportions of mallard and grey duck populations affected by lead poisoning in the Eastern Region each year could be substantially greater than might be indicated by one off snap shots investigating blood lead levels or the incidence of gizzards containing lead pellets, and overall, may be disconcertingly high. In the United States, a 5% incidence of ingested lead shot in the gizzards of hunter-harvested birds is used as the threshold above which lead poisoning in waterfowl populations is deemed to be "excessive" (US Fish and Wildlife Service 1986) and this criterion has been widely adopted elsewhere.

It is difficult to estimate mortality derived from the ingestion of lead shot as so many factors influence the extent to which an individual is affected as a consequence of ingesting lead. Diet is the single most important factor influencing lead absorption and toxicity (Pain 1992) but other factors include number of shot ingested, previous exposure to lead, and sex and age of the bird concerned. In the United States an annual mortality rate of 3.98% has been estimated for the North American mallard population (Bellrose 1959), while Thomas (1975) calculated it to be at least 4% for mallards in the Ouse Washes of England. Mudge (1983) calculated an all up mortality rate for mallards in Britain of about 2.3% which could be attributed to lead poisoning.

Banding studies in the Eastern Region indicate of present, a mallard population which numbers in the order of 300,000 birds (M. McDougall *pers comm*). If we were to assume an annual mortality rate due to lead poisoning of 2-4% here, the implication of this would be that 6,000-12,000 mallards die each year as a result of ingesting lead shot. What proportion of these birds might have succumbed to other unrelated causes or been shot anyway is speculative.

Scheuhammer and Norris (1995) estimated an annual waterfowl mortality for Canada based on an alternative approach in which they made the assumption that birds which had ingested three or more pellets would inevitably die. In their case they used a figure of 20% which they regarded as being a fair average for the proportion of birds falling into this category. This figure was then applied to the proportion of the population estimated to have ingested lead shot.

Of the studies conducted in New Zealand to date, the number of birds with three or more pellets in their gizzards as a percentage of all birds containing lead shot varies

from 5.4% in this investigation to 25% in Bellford's and 27.3% in that of Dyer's. If we were to speculate that 30% of the Eastern Region's mallard population ingests lead shot over the course of a year (and as previously discussed this figure could potentially be much higher), we would have to conclude an annual mortality of 30 multiplied by 0.054 to 30 multiplied by 0.273 = 1.6-8.2% or 4,800-24,600 birds. Again we would have to recognise that a proportion of these birds might have died anyway, either prior to the game season or prior to breeding, even if they had not ingested lead. Of the remaining 65,400-85,100 ducks which had ingested shot under this scenario, most, if not a large proportion, would have experienced sub-lethal effects including the likelihood of permanent physiological damage.

To put these figures into another perspective, the estimated mallard harvest for the Eastern region in 1999 was just over 38,500 birds (95% confidence interval = 32,500-44,885)(McDougall 1999).

5. Conclusions and Summary

1. Of 162 blood samples obtained from mallards and grey ducks within the Eastern Region during the late summer of 1998/99, between 15.4 and 18.5% were found to have elevated lead levels indicating the probable ingestion of lead shot within the preceding 5-8 weeks. Incidence varied from 2% at one location to 40% at another.

2. Of 458 mallard and grey duck gizzards collected by hunters during the 1999 game season from essentially the same locations, 8.95% contained lead shot which was considered to have been ingested. Again incidence was variable, and ranged from 2.3% to 14.1% across the region. The presence of lead shot within a gizzard indicates its probable ingestion within the preceding 3 weeks.

3. Neither blood lead levels nor observed incidences of lead shot in gizzards revealed any statistically significant differences in ingestion rates between mallards and greys, or males versus females. However, blood lead sampling did suggest that males may have been more inclined to ingest shot than females during the summer. Blood lead levels also suggested a higher ingestion rate in adults compared to juveniles.

4. No difference was detected in lead shot ingestion rates over the course of the game season though small sample sizes in some periods might have obscured such.

5. Most gizzards (71%) in which lead shot was recorded contained one pellet only.

6. There is likely to be a proportion of birds which suffer acute lead poisoning as a result of ingesting a large number (≥10?) of pellets. As a consequence these birds are not available to hunters nor therefore, are they recorded in hunter-derived samples.

7. The incidence of ingested lead pellets in gizzards is a less sensitive indicator of exposure to lead shot than measures of lead levels in blood. Typically the

incidence of above background concentrations of lead in blood exceeds that indicated from gizzard analyses.

8. The numbers of mallards and grey ducks which consume lead pellets over the course of a year, are likely to be considerably higher than the numbers or proportions of birds found to have pellets in their gizzards, or to have elevated blood lead levels at any one point in time.

9. Ingestion of a single lead pellet can be all that is required to kill a bird, but it has also been found that waterfowl which ingest only 1 or 2 shot more often live than die. In the case of dabbling ducks such as mallards and greys, ingestion of a single pellet is likely to produce sub-lethal toxic effects in a large proportion of birds. Such effects can be of a biochemical, physiological and/or behavioural nature, and can indirectly result in higher mortality rates through an increased risk of starvation, predation, disease or being shot.

10. Diet is the single most important factor influencing lead absorption and toxicity next to other factors such as number of shot ingested and previous exposure to lead. High protein, phosphorus and/or calcium diets ie more natural plant and animal foods, can mitigate the effects of lead. Conversely, mallards whose diets' comprise carbohydrates such as corn or cereal grains have been shown to be more susceptible to lead poisoning. This raises the question of the potential impact of pond feeding where birds are attracted to maize or other grains fed out over areas heavily shot over during the game season.

11. Insufficient information is available to accurately estimate mortality in mallard and grey duck populations of the Eastern Region as a consequence of ingesting lead shot, but the incidences of ingested shot and elevated blood lead levels observed in this study suggest resultant mortality, in some years at least, could be substantial. Over and above this a greater number of birds are likely to be permanently and sub-lethally affected.

12. The incidental observation of lead shot in two paradise shelduck gizzards in this study adds another species of waterfowl to the list of those which have been recorded as having ingested shot in New Zealand. That list now comprises mallard, grey duck, NZ shoveler, black swan, Canada goose, paradise shelduck.

6. Acknowledgements

Thanks to John Lucas for organising the materials for collecting the blood samples and for his assistance, and that of Matthew McDougall and Iain Maxwell's, in extracting the blood from our collections of live-trapped birds. Thanks also to the many hunters who contributed to the gizzard investigation which would have been very much more limited had they not been willing to do so. Special mention in this regard needs to be made of Greg Vercoe, Chris Ellery, Rob Gregory, Kim Mossman, Charlie Whitehead, Andre Terpstra, David Dods and Pete Cleaver. Other hunters included Steve Scragg, Dave Paine, Ray Bushell, Trevor Richardson, John Lucas, Iain Maxwell and Brett Bosley.

Simon Ward assisted with the initial processing of many of the gizzards while Matthew McDougall helped out with some of the x-ray work. I am particularly indebted to Ian McKenzie of Rotorua Central Veterinary Clinic for his interest and generosity in allowing me free and ready access to his x-ray facilities during this phase of the project. Rob Pitkethley provided a useful second opinion on the question of whether or not lead shot found in some gizzards should be categorised as having been ingested or shot-in.

Phil Teal, Zane Moss, Graeme Hughes and Matthew McDougall reviewed a draft of the report and I thank them for their comments.

Direct costs for the project were met from a grant from Fish & Game New Zealand's National Research Fund.

7. Literature Cited

Anderson, WL and SP Havera. 1985. Blood lead, protoporphyrin, and ingested shot for detecting lead poisoning in waterfowl. *Wildlife Society Bulletin 13:26-31.*

Anderson, WL and SP Havera. 1989. Lead poisoning in Illinois waterfowl (1977-1988) and the implementation of nontoxic shot regulations. *Illinois Natural History Survey Biological Notes 133.* 37pp.

Baxter, KL and R. Allcroft. 1950. The determination of lead in biological material. *Journal of Comparative Pathology and Therapeutics 60(2).*

Bellford, CJ. 1975. *Lead poisoning in mallards and grey ducks in Otago.* Diploma of Wildlife Management dissertation, University of Otago. 40pp.

Bellingham, M. 1991. Let them eat steel. *Forest and Bird 22(3): 43-44.*

Bellrose, FC. 1959. Lead poisoning as a mortality factor in waterfowl populations. *Illinois Natural History Survey Bulletin 27(3): 235-288.*

Beyer, WN, Spann, JW, Sileo, L and JC Franson. 1998. Lead poisoning in six captive avian species. *Archives Environmental Contamination and Toxicology17: 121-130.*

Caithness, TA. 1974. Lead poisoning in waterfowl. *Wildlife - A Review No.5:16-19.*

Chasko, GG, Hoehn, TR and P Howell-Heller. 1984. Toxicity of lead shot to wild black ducks and mallards fed natural foods. *Bulletin of Environmental Contamination and Toxicology 32: 417-428.*

Dieter, MP and MT Finley. 1978. Erythrocyte delta-aminolevulinic acid dehydratase activity in mallard ducks: duration of inhibition after lead shot dosage. *Journal of Wildlife Management 42:621-625.*

Dieter, MP and MT Finley. 1979. Delta-aminolevulinic acid dehydratase enzyme activity in blood, brain, and liver of lead-dosed ducks. *Environmental Research 19: 127-135.*

Dyer, JWA. 1991. Lead shot in gizzards of NZ mallards. *Flight 4/91 Issue 70:10-11.*

Falla, RA. 1936. Arctic birds as migrants in New Zealand. *Records of the Auckland Institute and Museum 2(1):3-14.*

Finley, MT and MP Dieter. 1976. Sub-lethal effects of chronic lead ingestion in mallard ducks. *Jounal of Toxicology and Environmental Health 1:929-937.*

Finley, MT, Dieter, MP and LN Locke. 1976. Lead in tissues of mallard ducks dosed with two types of lead shot. *Bulletin of Environmental Contamination and Toxicology 16(3):261-269.*

Finley, MT and MP Dieter. 1978a. Toxicity of experimental lead-iron shot versus commercial lead shot in mallards. *Journal of Wildlife Management 42:32-39.*

Finley, MT and MP Dieter. 1978b. Influence of laying on lead accumulation in bone of mallard ducks. *Journal of Toxicology and Environmental Health 4:123-129.*

Friend, M. 1985. Interpretation of criteria commonly used to determine lead poisoning problem areas. *US Fish and Wildlife Service Fish and Wildlife Leaflet 2.*

Garrick, AS. 1977-1979. *Pukepuke Lagoon Wildlife Management Reserve*. Eight unpublished monthly reports, Wildlife Service, Department of Internal Affairs, Wellington.

Havera, MJ, Anderson, WL and SG Wood. 1989. Use of blood from dead mallards to monitor lead poisoning. *Wildlife Society Bulletin 17: 241-244.*

Havera, MJ, Wood, SG, and MM Georgi. 1992. Blood and tissue parameters in wild mallards redosed with lead shot. *Bulletin of Environmental Contamination and Toxicology 49: 238-245.*

Havera, MJ and WL Anderson. 1999. Food contents of mallard gizzards with and without ingested lead or steel shot. *Transactions of the Illinois State Academy of Science 92(1&2): 89-94.*

Heitmeyer, ME, Fredrickson, LH and DD Humberg. 1993. Further evidence of biaises associated with hunter-killed mallards. *Journal of Wildlife Management 57(4):733-740.*

Hohman, WL, Pritchert, RL, Pace, RM, Woolington, DW and R Helm. 1990. Influence of ingested lead on body mass of wintering canvasbacks. *Journal of Wildlife Management 54:211-215.*

Jordan, JS and FC Bellrose. 1951. Lead poisoning in wild waterfowl. *Illinois Natural History Survey Biological Notes 26.* 27pp.

Koranda, J, Moore, K, Stuart, M and C Conrado. 1979. *Dietary effects of lead uptake and trace element distribution in mallard ducks dosed with lead shot.* Lawrence Livermore Laboratory Report, Livermore, California. 39pp.

Lobb, AJ, Rooney, CP and M Main. 1997. Initial investigation into lead contamination at clay target clubs and wetlands in Canterbury. *Canterbury Regional Council Technical Report R97(6).* 79pp.

Locke, LN and NJ Thomas. 1996. Lead poisoning of waterfowl and raptors. Chapter 10, pages 108-116 in A Fairbrother, LN Locke and GL Hoff (eds). *Noninfectious diseases of wildlife*. 2nd edition. Iowa State University Press, Iowa.

McDougall, M. 1999. *1999 banding report.* Unpublished Fish & Game New Zealand report. 30pp.

Montalbano, F and TC Hines. 1978. An improved x-ray technique for investigating ingestion of lead by waterfowl. *Proceedings of the Annual Conference of the Southeastern Association of Fish and Wildlife Agencies 32:364-368.*

Mudge, GP. 1983. The incidence and significance of ingested lead pellet poisoning in British waterfowl. *Biological Conservation 27:333-372.*

Pain, DJ. 1992. Lead poisoning of waterfowl: a review. Pages 7-13 in DJ Pain (ed). Lead poisoning in waterfowl. *IWRB Special Publication No. 16, Slimbridge, UK.*

Pain, DJ and BA Rattner. 1988. Mortality and haematology associated with the ingestion of one number four lead shot in black ducks, *Anas rubripes. Bulletin of Environmental Contamination and Toxicology 40:59-164.*

Rocke, TE and MD Samuel. 1991. Effects of lead shot ingestion on selected cells of the mallard immune system. *Journal of Wildlife Dissertations 27:1-9.*

Roscoe, DE. 1986. Diagnostic and survey techniques for lead poisoning in waterfowl. Pages 27-32 in JS Feierabend and AB Russell (eds). *Proceedings of a symposium on lead poisoning in wild waterfowl - a workshop.* National Wildlife Federation, Washington, DC. 139pp.

Roscoe, DE, Nielson, SW, Lamola, AA and D Zuckerman. 1979. A simple, quantitative test for erythrocyte protoporphyrin in lead poisoned ducks. *Journal of Wildlife Dissertations 15:127-136.*

Sanderson, GC, Norton, HW and SS Hurley. 1981. Effects of ingested lead-iron shot on mallards. *Illinois Natural History Survey Biological Notes 116.* 15pp.

Sanderson, GC and FC Bellrose. 1986. A review of the problem of lead poisoning in waterfowl. *Illinois Natural History Survey Special Publication 4.* 34pp.

Sanderson, GC and JC Irwin. 1976. *Effects of various combinations and numbers of lead-iron pellets dosed in wild-type captive mallards.* Final report US Fish and Wildlife Service and Illinois Natural History Survey, Urbana. 67pp.

Scheuhammer, AM and SL Norris. 1995. A review of the environmental impacts of lead shotshell ammunition and lead fishing weights in Canada. *Occasional Paper Number 88,* Canadian Wildlife Service, Environment Canada, Ottawa. 52pp.

Scheuhammer, AM and SL Norris. 1986. The ecotoxicology of lead shot and lead fishing weights. *Ecotoxicology 5:279-295.*

Shealy, PM, Newsom, JD and PJ Zwank. 1982. *A lead toxicity study of waterfowl on Catahoula Lake and Lacassine National Wildlife Refuge.* Report to Louisiana State University by Louisiana Co-operative Wildlife Research Unit. 77pp.

Stendell, RC, Smith, RI, Burnham, KP and RE Christensen. 1979. Exposure of waterfowl to lead: a nationwide survey of residues in wing bones of seven species, 1972-73. *US Fish and Wildlife Survey Special Science Report Wildlife No. 223.* 12pp.

Thomas, GJ. 1975. Ingested lead pellets in waterfowl at the Ouse Washes, England, 1968-73. *Wildfowl 26: 43-48.*

The Press. 1985. News item January 26, page 2.

US Fish and Wildlife Service. 1986. *Use of lead shot for hunting migratory birds in the United States. Final supplemental environmental impact statement.* Department of the Interior, Washington, DOC.

White, DH and RC Stendell. 1977. Waterfowl exposure to lead and steel shot on selected hunting areas. *Journal of Wildlife Management 41:469475.*

Williams, MJ. 1998. *An assessment of grey duck x mallard hybridisation.* A report to the New Zealand Fish & Game Council. 24pp.

Wisely, B and KH Miers. 1956. Lead poisoning in New Zealand waterfowl. *Department of Internal Affairs Wildlife Publication No. 41.* 11pp.

APPENDIX 1: Instructions associated with the collection of gizzards.

BRIEF FOR HUNTER CO-ORDINATORS FOR GIZZARD COLLECTION GAME SEASON 1999

Objective

The acquisition of at least 200 entire gizzards and associated heads from mallards, greys and hybrids of such from the Kaituna/Maketu Plains subregion[1].

- At least 100 to be obtained Opening Weekend and a further 100 from the remaining part of the season.

Materials (supplied)

- 250 plastic bags with twist-it ties.
- labels and pencils.

Approach

- Collection to be obtained from a limited number of hunters who can be relied upon to provide accurately labelled samples processed as per attached instructions.

- Hunters to be asked if they are prepared to assist include Bloggs, Bloggs, Bloggs, Bloggs and Bloggs.

- Bloggs and Bloggs will need to each collect, or co-ordinate the collection of, x samples on Opening Weekend and y during the remainder of the season (but if they wish they can collect more on the off chance that we'll be able to process them at some stage).

Instructions

- as per attached.

[1] There was a similar objective for each of the Aniwhenua/Galatea and Gisborne/Wairoa subregions.

INSTRUCTIONS FOR HUNTERS COLLECTING GIZZARDS FOR LEAD SHOT INGESTION STUDY

- we are at this stage only interested in mallards, greys or their hybrids (forget shoveler, paris, swan or geese).

- please do not consciously select birds eg for condition, sex, species or where they've come from, but simply take the first ten, twenty, or fifty birds or whatever it might be that are available or you can lay your hands on.

- remove the gizzard (= the dark red, hard muscular organ about the size of a small chicken egg) in one piece and place it entire, ie don't cut it open or empty its contents, into one of the plastic bags provided. Remove also, the head of the bird and make sure it goes into the same bag as did the gizzard from that bird.

- insert into that same bag, a label on which you have recorded in pencil (don't use a pen as the ink runs) the following four items of information:

  i) the **date** shot.
  ii) the specific **location** (not simply Te Puke or Murupara but Kaituna Reserve or Lake Aniwhenua for example).
  iii) The **species** ie whether it was a grey or a mallard, or if in your opinion a hybrid, whether it more closely resembled a mallard or a grey duck.
  iv) **your initials**.

- put a tie around the bag and get it into a freezer before the contents start to go off (please!).

- clearly a separate bag is required for each sample collected. Any problems please contact Matt or myself.

Many thanks for your assistance, we will let you know the outcome of this study in due course.

Andy Garrick
Fish & Game Officer
Eastern Region

15 April 1999

APPENDIX 2: Methods and costs associated with investigating the incidence of ingested lead shot and elevated blood lead levels in mallard and grey duck populations in the Eastern Region.

METHODS

1. Blood lead levels

During the course of Eastern Region's mallard and grey duck banding programme in February and March 1999, blood samples were collected from 162 birds at five trap sites. Sampling comprised a randomised stratified design in which at least 50 birds were randomly selected from each of three regional locations: the Kaituna/Maketu Plains, Aniwhenua/Galatea, and Gisborne/Wairoa. Between 1.5 and 2.5mls of blood was collected from each bird via a small incision made in the brachial vein with a scalpel.

[An alternative approach which has been used elsewhere and warrants further investigation is to use a hypodermic to extract the sample. We tried this with little success due we believe, to not having a needle of the right diameter. Too large a needle collapses and/or damages the vein, while too small a diameter is ineffective in extracting sufficient blood before it clots and blocks the hypodermic - we found duck blood coagulates very quickly. Bellford (1975) used a 22 gauge hypodermic with the needle bent to about 20° in the direction of the bevelled edge to facilitate venipuncture. It would be useful to conduct some trials with a vet or animal health technician on some captive birds].

Each sample was collected directly into a heparinised 2ml EDTA vial and placed into cold storage until delivery to a laboratory for analysis. Initially, samples (ex Gisborne and Aniwhenua) were processed by the Ruakura Animal Health Laboratory in Hamilton using a modified version of the colorimetric determination method described by Baxter and Allcroft (1950). This approach enables lead to be detected to levels of +/- 0.05mg/l (Mariette Komene *pers comm*). The resultant analyses indicated greater accuracy was desirable so the remaining 51 samples were despatched to the Institute of Environmental Science & Research in Wellington where they were diluted then analysed using an ICPM spectrophotometer. With this technique lead can be detected to levels of +/- 0.02mg/l (Sharon van Soest *pers comm*).

2. Examination of gizzard contents

During the game season, May-July 1999, 458 mallard and grey duck gizzards were obtained from waterfowl harvested by hunters in essentially the same three regional locations from which blood samples were collected the previous summer. Details of the

sampling process, which was again set up to be of a randomised stratified nature, plus the instructions provided to hunters, are given in Appendix 1.

Subsequent processing involved opening each gizzard and flushing its contents into a 250mm diameter bowl. These contents were then diluted with water and the less dense material, principally food remnants, decanted off with the cycle being repeated until such time as clean grit, and sometimes larger seeds, was all that remained. The residual material was then oven dried and packaged into a labelled 50 x 130mm zip lock plastic bag. The gizzard from which the contents were derived was then inspected carefully for perforations or any other indication that any pellets found might have been shot in as opposed to having been ingested. If the gizzard lining was heavily discoloured or sloughing, this too was recorded.

The presence of lead shot in gizzards was determined by analysis of x-ray radiographs of contents in accordance with the approach described by Montalbano and Hines 1978. Radiography was performed with an Atomscope 903 Type B-85 x-ray machine set at 50kV/35mA and an exposure of 0.08 seconds. Positive and questionable signatures were reshot at an exposure of 0.35 seconds to exclude all background and ensure any false or doubtful positives detected in the first round were not incorporated into the final analysis. Visual examination under microscope of the residual positives was then undertaken to differentiate between ingested and embedded shot, this determination being aided by the notes previously taken on whether or not pellet entry wounds were apparent in gizzard linings.

RESOURCES

1. Blood lead levels

- materials (EDTA vaccutainer vials, scalpel blades, meths, swabs etc) 94.00

- processing of blood samples

    - Ruakura Animal Health Centre @ $16 per sample 1600.00
    - ESR Wellington Science Centre @ $18 per sample 936.00

Total (exc GST) $2630.00

Each blood sample took approximately 5 minutes to extract and required two persons, one to hold, prepare and lance the bird, the other to collect and document the specimen. This operation was performed in concert with the aging, sexing and banding of birds (which was being carried out by others) so as to minimise the period over which birds were held prior to release.

2. Examination of gizzard contents

- materials (laboratory hardware, plastic bags, labels etc) 128.47
- laboratory assistance (student labour) @ $7.50/hour 146.25
- x-rays of gizzard contents
    - 550 samples/50 x-ray plates - koha/libation for the proprietor and staff of a local veterinary service 66.20

      [Ruakura X-Ray Centre quoted $120/hour for x-ray services, and on the basis of being able to fit 25 samples onto an x-ray plate with each plate taking 10 minutes to process, estimated an all up cost in the order of $550-600. I suspect however, that the actual cost might have been higher at the end of the day had we used these facilities as it took me in excess of 10 hours to process our collection of 467 samples.]
- x-ray and gizzard sample storage 25.00

Total (exc GST) $365.92

Gizzard studies require considerably more time to set up and run than blood sampling programmes. In addition to organising and servicing hunter collections, it took about an hour to dissect, extract and process 8-10 gizzard samples ready for x-raying. Half of the samples I processed myself, the remainder were done by a student under my supervision so the costs for employing the latter would have been at least twice that indicated above had I got him to process the lot. The x-raying was undertaken by myself with some part time assistance from Matthew McDougall which considerably speeded up the exercise. Nevertheless, as indicated above, in the order of a day and a half was required to obtain the x-rays. Interpreting the x-rays took a further 1-2 days as this included microscopic examination of all samples returning a positive. On top of this 1-2 days were needed to digitise and analyse data as was the case for processing data associated with the blood sampling programme.