Lead Poisoning of Game Birds

What is it?

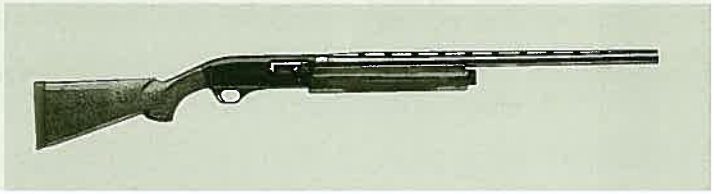
Game birds ingest grit to aid in the physical breakdown and digestion of the food they eat. If lead shot is available, they may ingest that too. Digestive juices and the grinding action of the gizzard reduce much of this shot into lead salts, which can then be circulated to vital organs via the bloodstream. Lead in this form can be highly toxic.

What effects does it have on game birds?

Exposure to lead can affect the physiological functioning of the circulatory, digestive, muscular, nervous, excretory, immunological, and reproductive systems. Acute poisoning usually follows the ingestion of a large number of shot and birds can die within a matter of days. Overseas experience has shown that more often waterfowl die of chronic lead poisoning, usually in very poor condition, two or three weeks after they ingest a small number of shot.

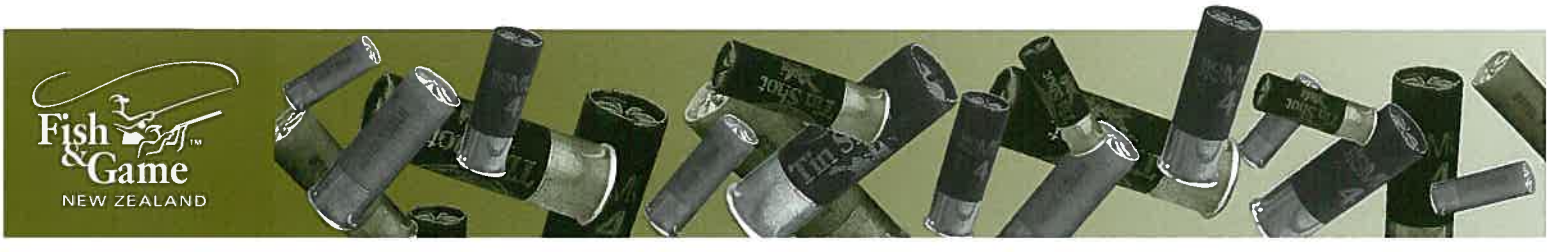
Ingestion of only one lead shot can be enough to kill a bird, though more often than not waterfowl that have done so survive. Among other factors diet can affect toxicity. For example, mallards whose diet comprises corn or cereal grains are more susceptible to lead poisoning than those feeding on more natural plant and animal foods high in protein.

If not directly lethal, ingestion of a single pellet can result in a wide range of sub-lethal effects including permanent brain damage. Such effects can be of a behavioural as well as an anatomical or physiological nature, and may indirectly result in higher mortality rates through an increased risk of starvation, predation and disease. Mallards which have ingested lead shot have been found to be more susceptible to being taken by hunters than birds which have not. There is evidence that lead poisoning may also reduce reproductive output.



What game birds are affected?

Lead shot poisoning of waterfowl was reported as early as the late 1800s and has been recorded from a wide range of species in North America, Canada, Europe and Australia. Typically the highest incidence of shot ingestion is found in diving ducks (eg scaups) followed by dabbling species (eg mallards) with the lowest incidence in grazing species (eg shelducks). Waterfowl that mostly feed in the water column, such as shoveler, are less likely to pick up lead shot than those which dig into bottom sediments. Lead shot ingestion has also been documented in a number of upland game bird species including bobwhite and scaled quail, ring-necked pheasant, ruffed grouse, mourning dove, grey partridge and turkey. Generally however, upland game populations are not affected to the same extent as waterfowl populations.



What evidence is there that it occurs in New Zealand?

Lead shot has periodically been reported in the gizzards of NZ waterfowl for over 50 years. Lead poisoning of mallards and grey ducks was recorded at Lake Waikare in the Waikato and at the Wairau Bar in Marlborough in the late 40s and early 50s, and in black swan at Woodend Lagoon near Christchurch about the same time. Mallards, grey duck and black swan that had succumbed to lead poisoning were reported from the Manawatu during the period 1969-1979. During the 1975 game season 5.7% of 279 mallard and grey duck gizzards obtained from hunters in Otago contained lead shot as did two shoveler gizzards. During the mid-1980s lead poisoning of Canada geese and black swans was reported at Lake Ellesmere.

Of 467 mallard and grey duck gizzards obtained during the 1990 game season in the Auckland/ Waikato Fish and Game Region, 4.7% contained ingested lead shot. Elevated lead levels were detected in the livers of five of 23 mallards examined from Ellesmere in 1996 and 10 pellets were also recorded from a shoveler gizzard.

Since February 1999, Fish and Game NZ has conducted further research involving both gizzard examination and blood lead level analyses of mallards and grey ducks, the results of which indicate that lead ingestion by these species is both a widespread and ongoing phenomenon in New Zealand. The results of the analyses of gizzards obtained from these birds during the 1999 or 2000 game seasons are as follows:

Fish and Game Region	No. of gizzards	Percentage* of gizzards with ingested lead shot
Auckland/Waikato	385	10.6
Eastern	458	9.0
Hawke's Bay	176	3.4
Nelson/Marlborough	66	3.0
North Canterbury	192	8.3
Central South Island	32	3.1
Southland	226	7.5

* These are "minimum" percentages as an additional 1.5% of all gizzards examined contained lead shot whose origin was unclear but in some instances could have been ingested.

Blood lead level analyses done in the Eastern Region in the summer of 1999 suggested that 15.4 to 18.5% of mallards and grey ducks within the areas sampled had consumed lead shot over the preceding 5-8 weeks. After making appropriate adjustments this result is very similar to the nine percent ingestion rate recorded from the gizzard sample taken later in the year. This study confirms earlier observations that lead shot ingestion is likely to be occurring throughout the year.

It is equally apparent however, that ingestion rates can be highly variable from place to place, season to season and from year to year, even at the same location.

Ingested lead shot was also recorded in two paradise shelduck gizzards obtained during the 1999 game season from the Bay of Plenty.

So what does this mean for game bird populations?

An important point to appreciate is that gizzard and blood lead level analyses only reflect the proportion of the population which has ingested lead shot within the few weeks preceding and not the all up number of birds which consume shot over the course of a year. This is because the digestive processes mean that pellets generally disappear from the gizzard within about three weeks of being swallowed, while blood lead levels only remain elevated for a period of about five weeks or so after lead has been ingested. For example, if we examined another sample of gizzards three weeks later, and then three weeks after that again, and so on, we would undoubtedly record further segments of the population which until then had not ingested lead shot, plus some of the survivors which previously had. This means that the total number of birds which could be affected by lead poisoning each year is likely to be considerably greater than the number recorded in one-off surveys such as gizzard sampling programmes undertaken solely during the game season.

Estimating how many game birds die or are sub-lethally affected by lead shot ingestion in New Zealand each year is difficult. Based on the ingestion rates observed here, experience from overseas, and an assumption that 30% or more of mallard populations may ingest lead shot each year, we can speculate that annual mortality rates for mallards could be in the order of 1.6 to 8.2% of many populations.

Unfortunately we do not know how big most regional populations currently are, except in the Eastern Region, where banding studies indicate a mallard population in the order of 300,000 birds. If we apply the mortality rates given above we would have to conclude that 4,800-24,600 birds may have died there from lead poisoning in 1999. Under this scenario, it is conceivable that a further 65-85,000 ducks might also have ingested lead shot, and that a large proportion of them would have experienced sub-lethal effects including permanent impairments. To put these figures into another perspective, the estimated mallard harvest for the Eastern Region in 1999 was somewhere in the vicinity of 38,000 birds. The question we must ask ourselves - in the context of diminishing habitat, a series of poor breeding seasons over much of the country in recent years and other mortality factors is: can we really afford losses which are as potentially great as these?

Studies in the United States since the introduction of non-toxic shot have indicated declining lead ingestion rates and a reduction in deaths from lead poisoning in a number of species including mallards. While the rate at which these declines have taken place has varied due to the high densities of lead shot remaining available in some wetlands, overall trends have been encouraging. It is reasonable to assume a similar situation will occur in New Zealand to the ultimate benefit of all waterfowl hunters.

As far as upland game is concerned there is currently no evidence to indicate that lead poisoning is a problem in New Zealand

The risk to aquatic and terrestrial life from lead shot

Background concentrations of lead

Lead is present throughout the environment. The average total lead concentration in New Zealand sub-soils, which are normally protected from the lead produced by human activities, is about 10 mg/kg. Surface soils and the sediments of streams, harbours and estuaries have higher concentrations partly because of historic run-off from roads when we used leaded petrol. The typical range of concentrations is about 30 to 200 mg/kg. Most freshwaters have dissolved lead concentrations less than 1 mg/m3 although total lead concentrations may be higher because of lead attached to suspended sediment. For comparison, one pellet of No 8 shot in 1 kg of soil or sediment would increase the total lead concentration by about 60 mg/kg.

The decay of lead in the environment

Metallic lead, for example, lead shot, changes its chemical form by reacting with oxygen in the air and water, a process called "oxidation". The products of oxidation form a crust on the surface of the metallic lead which is much more soluble than the lead itself and slowly dissolves in water.

Oxidation occurs wherever there is both oxygen and water, for example in soils, the surface layers of sediments, etc. It is the dissolution of these oxidised crusts that produces the dissolved lead in soils, sediments and waters.

The oxidised surface crusts on lead shot are both formed and dissolved more quickly in acidic waters. Other factors being equal, the dissolved lead concentrations in acidic waters in either soils, sediments or ponds and streams, will be higher than in neutral or alkaline waters.

The risk to aquatic life

The risk to aquatic life comes almost entirely from some of the dissolved forms of lead. These forms are said to be "bioavailable" (biologically reactive). In general, particulate forms of lead such as lead shot, lead attached to sediment particles etc, have no effect on aquatic life. These forms are not bioavailable.

Most open or standing waters in New Zealand are either neutral or slightly alkaline. In these waters lead shot oxidises and dissolves very slowly so that the increase in dissolved lead concentrations due to the shot is negligible in most circumstances. Only in stagnant ponds is there any likelihood of dissolved concentrations increasing above normal levels. This is, however, a remote likelihood because stagnant ponds are often deficient in oxygen so that the initial oxidation of the shot almost ceases.

A few open waters in New Zealand are slightly acidic. The most notable examples of these waters are those in the brown-coloured lakes and streams of the lower Waikato River catchment and West Coast. In most of these waters the acidity is due to the brown material, the "humic matter", but in some of the West Coast streams and lakes the acidity is due to drainage from coal seams. In these acidic waters, lead shot will dissolve more rapidly than in neutral or alkaline waters. Fortunately, the humic matter in these waters attaches to the dissolved lead to form "lead humic matter complexes" that are not bioavailable.

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So although these acidic waters can cause the relatively rapid oxidation and dissolution of lead shot, the dissolved lead produced has little effect on aquatic life. There are a few acidic geothermal lakes in the Rotorua and Taupo regions but these do not appear to be favoured habitat for waterfowl and the input of lead to these lakes is likely to be small.

The very slow rates of lead shot oxidation and dissolution in neutral or alkaline waters and sediments is slowed even further or stopped altogether if the shot is separated from oxygen for example, by settling deeper into the substrate. Lead in this situation poses no threat to aquatic life.

In general, shot sinks rapidly into organic-rich oozy mud of the type found in many permanently inundated swamps and ponds. These muds have no oxygen below the surface few millimetres and once the shot has sunk below this depth it can have no effect on aquatic life although it may still be available to water fowl. In some ponds, particularly in their near-shore shallow waters, although the mud might be very fine-grained, it can be quite firm. Lead shot falling on these sediments and also on sandy sediments, will remain exposed to water and oxygen until the shot is buried either by wind mixing of the sediment or by new sediment depositing on top.

The risk to terrestrial life

Shot falling on soil can remain exposed to oxygen for long periods of time until either the shot is buried by accumulating dead vegetation or the soil is cultivated. Overseas work indicates that a pellet might sit on the surface of an undisturbed soil for 100 to 300 years before it completely dissolves. New Zealand soils are either neutral or slightly acidic and lead shot within the oxygenated zone of these soils will slowly oxidise and dissolve. Humic matter is present in most soils in relatively large amounts compared with waters and this humic matter forms complexes with some of the dissolved lead. Although these complexes can be leached from the soils into stream or ponds, the complexes are not bioavailable. Dissolved lead formed in soils but not complexed with humic matter is usually fixed very strongly to the soil particles.

The risk to terrestrial animals from lead shot arises through either the direct ingestion of soil containing shot, for example, both sheep and cattle ingest small amounts of soil, or through eating plants that have accumulated dissolved lead formed by oxidation of shot in the soil. Research has shown that grazing animals can ingest shot but it appears that very little of the lead ends up in the animals' tissues. Plants do not, in general, accumulate sufficient amounts of lead in their leaves to pose any risk to grazing animals. Lead does accumulate in plant roots but unless the soils are severely contaminated with soluble forms of lead, the concentrations in root crops are likely to be too low to be hazardous to animals. Such severe contamination is unlikely to result from lead shot.

Summary

In most New Zealand freshwaters lead shot dissolves too slowly to produce enough soluble lead to harm aquatic life. Only in a few slightly acidic waters will lead shot dissolve quickly enough to increase dissolved lead concentrations. In most of these waters, however, aquatic life will be protected from the lead by the presence of brown humic matter. Even in slightly acidic soils, which are common in New Zealand, the oxidation rate of lead shot is likely to be slow. The small amounts of dissolved lead produced from lead shot in soils is either strongly fixed to the soil or reacts with humic matter to form complexes that are not bioavailable. The risk posed by lead shot to terrestrial animals from either ingesting soil containing lead shot or by eating plants contaminated

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