Lead Shot Deposition and Distribution In Southern Nevada

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ABSTRACT

Densities of lead (Pb) shot in soil and the presence of Pb shot in waterfowl gizzards from past hunting activities at the Overton Wildlife Management Area (OWMA) in southern Nevada were determined. Soil shot densities in fields managed for doves, pheasants and geese, and adjacent fields strictly managed as waterfowl habitat were examined. Soil shot densities ranged from 2,691 to 107,642 Pb shot/ha in waterfowl areas to 649,085 to 862,275 Pb shot/ha in dove management areas. Pb shot deposition rates for the 1998-1999 dove hunting season were also calculated and ranged from 8,970 to 22,559 shot/ha in fields managed primarily for doves. Seventy-one waterfowl gizzards were collected from this management area and examined for the presence of shot. Five percent of the gizzards contained lead shot, with individual birds ranging from 0-5 shot per gizzard. Concentrations of lead shot in the soil at the OWMA are clearly elevated in the fields managed for dove habitat, and the use of Pb shot in these areas could be influencing elevated lead shot densities in the adjacent waterfowl management areas. Seasonal cultivation practices may be influencing the surface availability and depth of Pb shot present in the soil and should be more thoroughly examined before implementing their use as long-term management practices.

Keywords: doves, gizzards, lead shot, Overton, waterfowl

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INTRODUCTION

Considerable controversy has been generated over the past several years regarding the use of “nontoxic shot” for hunting waterfowl. For many years, lead (Pb) was exclusively used for waterfowl hunting without regard for its potential toxicity, even though reports of waterfowl diagnosed with Pb toxicosis have surfaced each decade since 1900, and such reports have increased in frequency since 1950 (Pain 1992).

A landmark study by Frank Belrose (1959) estimated 2-3 % of all North American waterfowl die annually of Pb poisoning. In this study, Belrose suggested the use of iron shot to overcome potential environmental toxicity problems, but this suggestion was not incorporated into regulatory practice until 1974 when the U.S. Fish and Wildlife Service (USFWS) required the use of steel shot for waterfowl hunting in certain areas of the United States (U.S. Fish and Wildlife Service 1974). Even with this requirement in place, waterfowl poisoning from Pb ingestion remained a growing concern. Thus beginning with the 1991-92 hunting season, the USFWS mandated the use of nontoxic shot for all waterfowl hunting in the United States. At that time, steel (Fe) was the only shot type approved for waterfowl hunting, although bismuth and tungsten have subsequently been approved.

Other wildlife species have also been affected by the ingestion of Pb shot, thus management efforts have begun to branch out to other game species such as doves (Zenaida sp.). Doves are not migratory waterfowl, and thus may still be hunted with Pb shot in many areas. Because cereal grains are planted in numerous areas across the country to attract doves, hunting pressure and subsequent shot deposition has been effectively concentrated into relatively localized areas. Recently, many state and federal management areas have identified continuing Pb poisoning problems, and have subsequently banned the use of Pb shot for all hunting within their management boundaries. However, this ban has not been instituted universally, and Pb shot can still be used in many hunting areas, including numerous state and federal lands.

At the Overton Wildlife Management Area (OWMA) in Clark County Nevada, located on the northern boundaries of Lake Mead, migratory birds, upland game, and migratory waterfowl are all hunted in very close spatial and temporal proximity, providing the potential for multiple bird species to be exposed to Pb shot. Therefore, we assessed current deposition and distribution of Pb shot from hunting activities at the OWMA by examining soil samples and evaluating annual Pb shot deposition rates. In

addition we collected gizzards from hunter harvested migratory waterfowl to determine if waterfowl killed at OWMA had been exposed to lead shot somewhere along their migratory path. The overall goal of this project was to determine if the continuing use of Pb shot in this managed hunting area is contributing to soil Pb shot densities that could create long-term management concerns.

METHODS

Field Choice

Management fields at OWMA are numbered in accordance with the blind number assigned to them during the waterfowl hunting season. But because some fields contain multiple blinds, we renamed each field with a unique identifying letter of the alphabet. (Figure 1). Samples were collected from four fields, two managed for doves (E and N) and two managed for ducks (C and D) (Figure 1). Field C was 0.8 ha, covered in bullrush, and was flooded before waterfowl season to a depth of approximately 1 m. Field D was 1.1 ha and was similar to field 4 in appearance and management. The soil type of both of these fields was loam that retained a high water content year-around. Field E was 4.2 ha and was tilled and planted in sunflowers in the spring to attract doves, and subsequently mowed in the fall before waterfowl season to attract geese. Field N was 6.7 ha and was similar in appearance and management to field E. Field E had a sandy loam texture, while N had a dense, clay soil structure.

Twenty-nine forms were placed in field N, while forty-four forms were placed in field E on 28 August 1998 and removed on 26 September 1998 (Figure 1). These dates correspond with the Nevada dove season which begins 1 September and ends 30 September.

Soil Samples

A total of 122 soil samples were collected from OWMA in the spring of 1998 and 1999. The number of samples taken per field was determined by the relative size of each field. In April 1998, thirty-six soil samples were collected from field E by delineating transects 100 m apart and removing a 15cm x 15cm x 15cm soil sample every 150 m along each transect. Similarly, 18 samples each were collected from fields C and D using 100 m x 100 m sample intervals. In March 1999, 50 soil samples were collected from field N. Samples were transported back to the laboratory where they were sieved using multi-layered soil sieves with mesh diameters ranging from 1.25 cm down to 600 um (#30 mesh). Following the initial screening, soil samples were dissolved in 19 L buckets of water and passed through the sieves for a second screening. Shot densities and percentages were calculated, and results from the samples were converted to shot/ha and compared to published studies.

Annual Shot Deposition Estimates

To estimate the average annual input of Pb shot to the management fields, we constructed wooden forms with internal measurements of 30.5 cm x 30.5 cm. Forms were constructed with 5 cm x 5 cm wood, and attached with liquid nails and a wood screw in each of the four corners. Each form was then covered with standard fiberglass screen attached with staples around the outside of the form. Forms were placed in the field by delineating line transects 100 m apart and sampling every 150 m along these transects. Each form was placed on the ground, lined with newspaper and filled with 60 grit silica sand. Upon collection, the newspaper was removed allowing the silica to readily pass through the fiberglass screen, leaving behind the shot and other materials.

Gizzard Samples

Seventy-two gizzards from hunter-harvested waterfowl were collected throughout the 1998-99 hunting season which ran from 1 November 1998 through 16 January 1999. Hunters were approached at the mandatory check station and asked to donate gizzards from the birds they harvested. Study personnel removed bird entrails and recorded the species, sex, and date and location of collection for each sample. Gizzards were transported back to the laboratory and immediately frozen. For inspection, gizzards were thawed and examined for the quantity and type of shot present. A radiographic method was employed first, followed by a manual dissection. Shot was identified as Pb, steel, bismuth or tungsten and the diameter of all shot found was determined using a caliper. Shot size was determined by use of a caliper, capable of measuring to 1/20 of a cm. Shot that was dented or deformed was measured for a maximum and minimum diameter and the average reported.

Radiography. For radiography of the gizzard specimens, a Schimadzu, single phase radiographic unit with a 500 mA, 125 kVp generator was utilized. Table-top exposures were made using Kodak X-Omatic cassettes (14 x 17)MBI-G; double emulsion medical radiographic film was used. Exposures were 100 mA (small Focal Spot), 0.05 seconds and 46 to 50 kVp. The gizzards varied in size from 2.0 cm to 4.5 cm, thus killivoltage was adjusted accordingly. Due to size variations, the number of gizzards exposed per film varied from 8 to 10, and all

gizzards were labeled with Pb numbers to aid in later identification.

Manual Dissection. Gizzards were also manually dissected following the radiography examination. Investigators had no prior knowledge of results from the x-ray tests to avoid biasing dissection efforts. The number of shot present in the gizzards was determined by first examining the gizzards for external hole(s) indicating possible penetrating shot. Gizzards were then cut in half with a knife and the contents passed through soil sieves with #5 and #13 mesh diameter. The contents of the gizzards were flushed with water and examined for the presence of shot. The contents of the gizzards were then placed in a sample bag and frozen for subsequent identification.

Shot Identification

Several shot types are currently used for hunting upland game and waterfowl, thus it was imperative to have an assay which could accurately differentiate shot type in environmental samples (gizzards and soil). Two methods, radiographic and chemical, were developed and employed. The radiography method involved using a densitometer to measure the density of each sample, and attempted separation of the metals based on the density of each sample. The chemical method used dilute hydrochloric acid to differentiate between shot types (S.L. Gerstenberger, unpublished data). Because the acid causes a different reaction with each metal, differentiation between metals was possible. Due to variable thicknesses of spent shot and similar densities between each of the metals, density measurements could not differentiate between the metals. Thus, shot type was determined for all samples using the chemical method.

RESULTS

Soil Samples

Of the thirty-six samples collected from the dove field E, 30 samples (83%) contained Pb shot, while one contained bismuth, and none contained steel or tungsten. This equated to an estimate of 862,275 Pb shot/ha. Of the eighteen samples collected from field C, 8 samples (44%) contained shot of some type; 2 of those contained only Pb shot, 2 contained only steel shot, and the other 4 samples contained both steel and Pb shot. This resulted in an estimated concentration of 107,642 Pb shot/ha for field C. Of the eighteen samples collected from field D, 17% contained shot of some type; 6% of which was Pb shot and 11% of which was steel shot. An estimate Pb shot density of 2,691 shot/ha was calculated. No bismuth or tungsten shot were found in Fields C or D. Fifty-eight soil samples were collected from field N, and a total of 99 shot were recovered. Of these, 88 (89%) were Pb, 5 (5%) steel and 6 (6%) bismuth. This equated to an estimate of 649,085 Pb shot/ha. Shot sizes for all lead shot found are listed in Table 4 and indicate that shot sizes 6-9 comprised 95% (143/149) of shot recovered from fields and forms. The shot sizes found are consistent with the size recommended by most manufactures for dove and quail hunting.

Form Sampling

Of the 29 forms placed in field N, only 24 were recovered and used in calculations. The other five samples were lost due to a rise in the water level of Lake Mead or otherwise disturbed, as evidenced by human tracks leading to them in the mud, and thus excluded from the data set. An annual deposition average of 8,970 Pb shot/ha was calculated for this field, although this estimate may be slightly low due to tampering and lost forms.

Of the 44 forms placed in field E, 43 were recovered. Fifteen of the forms on the north end of the field had to be removed one week early to allow Nevada Division of Wildlife (NDOW) personnel to cultivate the field for planting. Because most dove hunting pressure comes in the early part of the season, it was felt this removal did not strongly influence deposition results. In addition, three forms were disturbed and thus had to be excluded from the data set. An annual deposition average of 22,559 Pb shot/ha was calculated for this field.

Gizzards

A total of 71 duck and goose gizzards were obtained from hunters during the 1998-1999 season (Table 1). Of the 71 gizzards examined, 8 (11%) clearly showed the presence of ingested shot, with 5.6% of the shot consisting of Pb. Two redhead gizzards contained all the lead shot ingested, which comprised of 2.8% of the total sample. Ingested and impacted shot was easily differentiated by examining the radiographs. Eighteen shot could clearly be seen in the gizzards as being ingested, with a range from 0-5 shot found per individual gizzard.

DISSUCISION

The presence of Pb shot in approximately 3% of all waterfowl gizzards examined indicates that waterfowl are still ingesting Pb shot somewhere along their flyway. But a major limitation of gizzard data is the impossibility of determining the residence time of birds in the immediate vicinity, thus determining if the shot was ingested while feeding at OWMA or elsewhere along the flyway. But however limited in application, these results do give a

positive indication of the bioavailability of spent Pb shot along this flyway, and further justification for examining Pb shot densities at OWMA.

Because OWMA is located within close proximity to a major urban center, Las Vegas, it receives very intense hunting pressure (Table 4). It is also unique in that it allows and promotes hunting of multiple species on a very small parcel of land with both Pb and non-toxic shot. Fields E and N were seeded in sunflowers and managed to improve habitat for doves, pheasants and geese (both lead and non-toxic shot used), while fields 4 and 5 were seeded with bullrush and managed for migratory waterfowl (non-toxic shot only). The intervening areas between the fields are mixed shrubs and serve as very good upland game habitat, but the straight-line distance between these fields is only several meters. This may provide the opportunity for continued Pb ingestion in both game and non-game species residing or migrating through the area, as discharged Pb shot from hunter activity can easily be dispersed throughout the entire management area.

Compared to existing literature, soil Pb pellet densities in the dove fields at OWMA are similar to those found prior to the 1986 ban on Pb shot (Table 3). However, it should be noted that the depth of soil sampling varied in the reported studies making direct comparisons difficult. Previous investigations determined that shot densities are reduced in the top several cm of soil after cultivation (Buck 1998; Fredrickson et al 1977), but the influence of these practices after 40-50 years of activity has not been clearly demonstrated. NDOW personnel annually cultivate OWMA's dove fields using a moldboard plow which completely overturns the soil. This turning could potentially homogenize the distribution of shot throughout the soil strata over extended periods of time. Other types of cultivation that do not "turn-over" the soil, such as a chisel plow, may reduce the availability of Pb shot over longer time periods, but limited data exists with respect to the effects of long-term tillage practices on Pb shot movement in soils.

One obvious solution to the problem of Pb shot ingestion by waterfowl and other gamebirds is to ban the use of all Pb shot from the management area. However, costly Pb shot alternatives (steel, bismuth, and tungsten) may prohibit many hunters from participating in dove hunting activities, and may ultimately reduce the number of hunter-use days on an area. This, in turn, could impact the ability of a management area to maintain adequate funding levels. The number of hunter-use days is often one of the primary factors used in determining resource allocation to state-owned management areas. In addition many conservation projects are funded from hunting related purchases, and reduction in the number or quality of hunting experiences could negatively influence funding availability. Therefore, finding a way to reduce the price of currently manufactured non-toxic shot or continuing the search for an inexpensive Pb substitute still seems warranted.

Preventative actions to reduce Pb exposure in waterfowl and other game species from hunting activities seem warranted. Several promising alternatives include the ban of Pb shot for all species, integrated tillage practices which have been shown to reduce shot availability, or the creation of buffer zones which minimize the shot which is being deposited into fields managed for waterfowl production. To make results more universally comparable, a more accurate soil sampling technique should be designed and should take into account soil type, existing tillage practices, time of year (pre- or post-season), and appropriate sampling depth. Finally, further research is needed to address the effectiveness of long-term management strategies designed to minimize exposure to Pb shot in heavily-used hunting areas. Future management strategies should also focus upon the reduction or elimination of Pb shot deposition from hunter activities to ensure non-toxic zones are not inadvertently impacted by adjacent hunting practices.

This paper was presented to the Nevada Division of Wildlife representatives from the Overton Wildlife Management Area, discussed at regional meetings and was the basis of a new Nevada regulation requiring the use of non-toxic shot in all Nevada Wildlife Management Areas. The new regulations were effective starting in the 2003 Nevada Hunting Seasons, more details can be found at the following link:
http://ndow.org/about/news/archives/072203_shot.shtm

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Table 1. Annual waterfowl harvests, waterfowl use days and hunter activity for the Overton Wildlife Management Area 1992-1998.

Year	Ducks Harvested	Geese Harvested	Waterfowl Hunters	Waterfowl Use Days
1992-1993	900	202	1405	897,000
1993-1994	1040	141	1361	478,140
1994-1995	1256	80	1632	729,372
1995-1996	1179	33	1337	692,355
1996-1997	1355	103	1748	556,620
1997-1998	1275	84	1414	N/A

*Number of dove and upland game hunters using the OWMA was not available.

Table 2. Prevalence of ingested shot in gizzards collected from the Overton Wildlife Management Area during the 1998-1999 waterfowl season.

Species	Collected	birds w/ shot	Total Shot
Shoveler	14	0	0
Greenwing Teal	10	1	1
Bufflehead	4	0	0
Goldeneye	1	0	0
Ruddy	2	0	0
Lesser Scaup	2	0	0
Canvasback	1	1	1
Ringneck	3	1	5
Gadwall	3	0	0
Pintail	4	0	0
Widgeon	3	0	0
Coot	1	0	0
Greater Scaup	1	0	0
Redhead	9	3	7 (4Pb shot in two ducks)
Mallard	11	2	4
Ross' Goose	1	0	0
Snow Goose	1	0	0
Total	71	8	18

Table 3. Comparison of lead pellet densities in soil samples taken from waterfowl and dove hunting areas.

Lead Shot/Ha	Region	Reference
0-1,840,000	Denmark	Peterson & Metlofte ‘79
8,608-292,000	USA	Bellrose ‘59
15,750-2,229,700	USA, Ca	Rocke et al ‘97
20,388-300,000	UK	Mudge ‘84
41,900-125,970	Canada	Bellrose ‘59
59,541-140,324	USA	Longore et al ‘82
75,347-384,271	USA, Illinois	Buck ‘98
60,149-544,748	Spain	Guitart et al ‘94
<64,000-2,000,000	France	Pain ‘91
71,000-862,275	This Study	This Study
1,676,300	USA, Texas	Fisher et al ‘86

Table 4. Average diameter of spent Pb shot recovered from fields and gizzards.

		Number of shot found	
Shot Size	Diameter (mm)	Fields	Gizzards
2	3.52-4.17	2	0
4	3.17-3.51	3	0
5	2.91-3.16	1	0
6	2.58-2.90	14	0
7.5	2.33-2.57	54	0
8	2.21-2.32	41	1
8.5	2.09-2.20	21	1
9	1.66-2.08	13	0
12	<1.66	0	2

* Categories for shot diameters were modified from the Winchester reloading guide and NRA firearms fact book.

Figure 1. Map of the Overton Wildlife Management Area in southern Nevada, showing the locations of all the management fields and the corresponding blind numbers used during waterfowl season.