Blood lead levels in avian scavengers: a comparison of urban and rural regions in the Pacific Northwest

*** Preliminary Report ***

Audubon Society of Portland

Founded in 1902

Photo: J. Cruce

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Introduction

Lead poisoning in terrestrial wildlife from the ingestion of lead bullet fragments is of high conservation concern across the country (Rattner et al. 2008, Pain et al. 2009) and worldwide (Fisher et al. 2006). In the United States and many other countries, lead toxicity from ammunition and fishing sinkers are the primary sources of new lead in the environment, as other anthropogenic sources (e.g. paint, gasoline, etc.) have largely been controlled by regulation. Substantial evidence indicates that large game animals that are shot but not retrieved from the field (or whose lead-contaminated gut piles are left behind) provide the primary source of lead poisoning for non-target wildlife (Rattner et al. 2008). Birds that will readily scavenge carcasses—including vultures, diurnal raptors (eagles, hawks, and falcons), owls, and corvids (jays, crows, and ravens)—are particularly susceptible to lead poisoning through this pathway (Fisher et al. 2006, Pain et al. 2009). Avian scavengers are either directly poisoned by feeding on contaminated carcasses or may pick up lead by consuming prey that had previously been shot with lead ammunition but survived.

The California Condor (*Gymnogyps californianus*) provides the most dramatic example of the catastrophic impact that lead poisoning can have on wildlife populations. Lead poisoning from ingested bullet fragments is the main source of condor mortality and evidence strongly suggests it is preventing the recovery of this critically endangered species (Finkelstein et al. 2012, Rideout et al. 2012). These recent findings spurred the state of California to officially ban the use of all lead ammunition (Appropriations Bill 711). The ban will go into effect in 2019.

Wildlife rehabilitation centers provide an important service to communities by providing treatment and care for sick, orphaned, and injured wild animals. The Audubon Society of Portland Wildlife Care Center (ASoP) accepts over 3,000 birds and animals every year, serving the City of Portland and the surrounding region (Fig. 1). Blue Mountain Wildlife (BMW) in Pendleton, Oregon annually accepts 600-700 wild animals (mostly birds) from rural areas of eastern Oregon, southeast Washington, and western Idaho (Fig. 1). In

Figure 1. Location of the Audubon Society of Portland Wildlife Care Center (ASoP) and the Blue Mountain Wildlife Care Center (BMW)

Veterinarian Deb Sheaffer extracting blood from a Bald Eagle at the ASoP (Photo: T. Hunsdorfer).

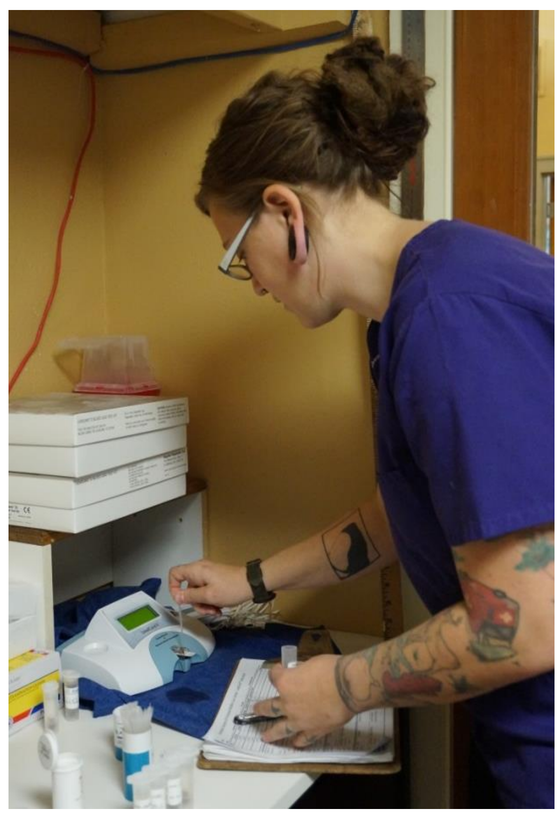
addition to providing care, wildlife rehabilitation centers can also provide data that allow researchers to learn more about other stressors in the environment, including lead toxicity.

The specific objectives of this study are to 1) Determine the prevalence of lead poisoning in avian scavenger species received by the ASoP and BMW; 2) Examine patterns of lead poisoning between sites, seasons, species, age classes, and sex classes; and 3) Determine presence of radiographic or clinical signs indicating lead toxicity in sampled birds (at ASoP only).

We predict lower blood lead levels in birds recovered from urban areas because big game hunting in these areas is absent or limited. Secondly, we predict that frequency of lead poisoning for the birds collected from rural areas will be highest from late fall to early spring during big game hunting season (elk and deer) and when coyote hunts are most intense (http://www.dfw.state.or.us, Stauber et al. 2010). We intend the results of this study to inform the broader policy discussions regarding the impact of lead on Oregon wildlife populations, as well as to help wildlife rehabilitators provide better care for wild animals.

Methods

Attempts were made to sample all birds of prey (eagles, hawks, falcons, and owls), Turkey Vultures, and Common Ravens received by each wildlife care center. At ASoP, blood samples were collected during the period 1 January to 31 December 2013. At BMW, samples were collected from 8 March 2010 to 31 December 2013. Birds were received by the care centers because they were believed to be sick, injured or orphaned. We attempted to sample all birds regardless of whether they exhibited



Lacy Campbell testing a blood sample using the LeadCare II Analyzer at the ASoP (Photo: J. Liebezeit)

clinical signs suggesting lead poisoning.

Blood samples were collected by venipuncture from the jugular, basilic, or metatarsal vein into a heparinized syringe. The LeadCare® II Analyzer was used to test blood lead levels (BLLs) at both care centers. The machines were periodically re-calibrated to ensure proper quality control. The LeadCare® II Analyzer is unable to determine BLL > 65 µg/dL. At the ASoP, all blood lead levels > 20 µg/dL were sent to an outside laboratory for confirmation (Idexx Veterinary Services). At both ASoP and BMW, blood samples were drawn and tested within one day of animal intake. At ASoP, all birds were radiographed to detect the presence of metal fragments in the gastro-intestinal tract and 47 clinical signs were assessed for each bird (see appendix) with special care taken to note signs consistent with heavy metal or lead poisoning.

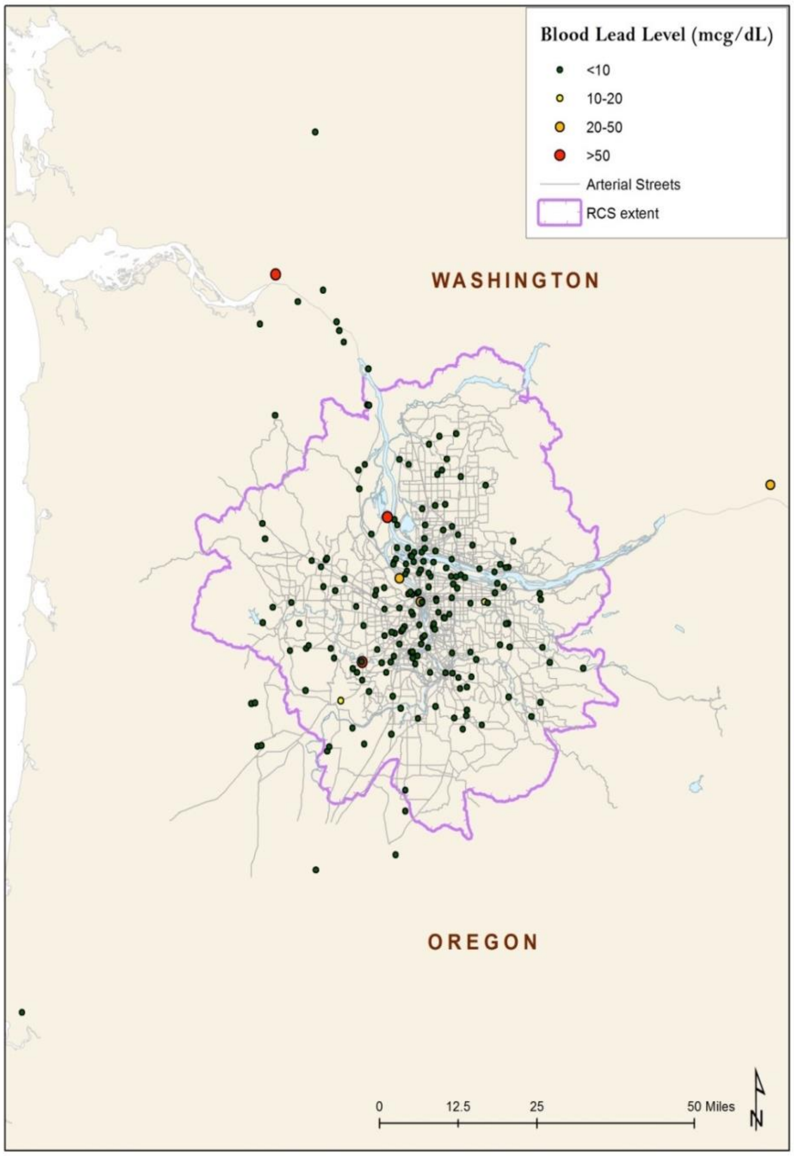


Figure 2. Map of recovery locations for birds sampled for blood lead level at Audubon Society of Portland Wildlife Care Center (ASoP). Most birds sampled were from Portland, Oregon, and the surrounding region. RCS= Regional Conservation Strategy boundary.

For analysis, we categorized BLL into four categories, with samples <10 µg/dL considered to be "Background level," 10-20 µg/dL = "Elevated exposure," >20-50 µg/dL = "Subclinical poisoning," and >50 µg/dL = "Clinical poisoning." These classifications are based on those used by other wildlife researchers (Rattner et al. 2008, Kelly and Johnson 2011). We used Microsoft Excel 2010 to conduct descriptive analyses for data summaries. ArcGIS 10.2 (ESRI 2013) was used to display locations of lead-tested birds (ASoP only). We used chi-square 2x2 contingency table analyses (Zar 1999) in statistical software NCSS 8 (Hintze 2012) to test for differences in frequency of elevated lead levels between sites, seasonally, and among age and sex classes. In cases when a cell in the contingency table had a value less than five, we used a Fisher exact test, which is more robust with lower sample sizes (Zar 1999). All statistical tests were considered significant at a P-value ≤ 0.05.

Results

At ASoP, 208 of 286 avian scavengers were tested for lead during 2013. We were unable to test 78 birds because they died prior to testing (*n=34*), we were unable to draw a sufficient quantity of blood for various reasons (*n=21*), birds were immediately released upon arrival (*n=17*), human error interfered (*n=5*), or birds were transferred to ASoP after several weeks in another facility (*n=1*). At BMW, 132 of 156 avian scavengers were tested during the study period. Twenty-four went untested because birds were dead on arrival (*n=8*), were in poor physical shape to allow sampling (*n=7*), and due to human error (*n=9*).

Birds admitted to the ASoP came largely from the Portland metro region (Fig. 2). One hundred eighty-six of the 208 birds (90%) were recovered from within the Regional Conservation Strategy boundary which surrounds the urban/suburban grid (Fig. 2). Of the 22 birds outside of the urban / suburban grid, two had elevated BLLs, including a Bald Eagle (*Haliaeetus leucocephalus*) recovered from Longview, Washington (>100 µg/dL) and a Red-tailed Hawk (*Buteo jamaicensis*) recovered from White Salmon, Washington (49.1 µg/dL). Specific location points for birds admitted to BMW were not recorded although they were known at the regional level to be from rural areas of eastern Oregon (*n=90*), SE Washington (*n=64*), and western Idaho (*n=2*).

A total of 20 bird species were sampled at both sites (16 at ASoP, 7 at BMW) including 11 diurnal raptor species, seven owls, Turkey

Table 1. Species breakdown of lead tested birds by taxonomic guild and number of birds tested at each care center (species listed in taxonomic order). Number of bird with BLL greater than background level (>10 µg/dL) are included in parentheses.

Species	Number tested ASoP (2013 only)	Number Tested BMW (2010-13)
Turkey Vulture (*Cathartes aura*)	6	1 (1)
DIURNAL RAPTORS		
Osprey (*Pandion haliaetus*)	11	0
Bald Eagle (*Haliaeetus leucocephalus*)	9 (1)	11 (6)
Sharp-shinned Hawk (*Accipiter striatus*)	4	0
Cooper's Hawk (*Accipiter cooperii*)	16 (1)	0
Swainson's Hawk (*Buteo swainsoni*)	0	3 (1)
Red-tailed Hawk (*Buteo jamaicensis*)	63 (4)	88 (7)
Rough-legged Hawk (*Buteo lagopus*)	0	2 (2)
Golden Eagle (*Aquila chrysaetos*)	0	26 (12)
American Kestrel (*Falco sparverius*)	12	0
Merlin (*Falco columbarius*)	1	0
Peregrine Falcon (*Falco peregrinus*)	8	0
OWLS		
Barn Owl (*Tyto alba*)	9	0
Western Screech Owl (*Otus kennicottii*)	28	0
Great Horned Owl (*Bubo virginianus*)	23 (1)	0
Northern Pygmy Owl (*Glaucidium gnoma*)	1	0
Barred Owl (*Strix varia*)	13	0
Long-eared Owl (*Asio otus*)	1	0
Northern Saw-whet Owl (*Aegolius acadicus*)	3	0
Common Raven (*Corvus corax*)	0	1
TOTAL	**208**	**132**

Vulture (*Cathartes aura*), and one corvid (Common Raven; *Corvus corax*) (Table 1). Diurnal raptors (eagles, hawks, and falcons) were the most frequently sampled group and within that category, Red-tailed Hawks were the most frequently sampled species at both sites.

Thirty-six of the 340 birds (10.5%) had blood lead levels greater than background levels (>10 µg/dL). Twenty of those birds had levels consistent with sub-clinical or clinical lead poisoning (>20 µg/dL) (Table 2). Both eagle species and Red-tailed Hawks made up the majority of species with elevated BLL (30 of 36; 83%) (Table 1). For Red-tailed Hawks, this contribution is not surprising since they were, by far, the most frequently sampled bird. The percentage of Red-tailed Hawks with elevated BLL was relatively low (11 of 151; 7.3%). However, for the eagles, a significant proportion of the birds sampled had elevated BLL: 12 of 26 (46%) for Golden Eagle and 7 of 20 (35%) for Bald Eagle. Only one of the 78 owls tested (1.2%) had elevated BLL. This individual was a Great Horned Owl recovered from outer southeast Portland. Of the seven Turkey Vultures tested, only one (sampled at BMW) had elevated BLL (Table 2).

For diurnal raptors, BMW had a significantly higher number of birds with BLL beyond background levels than did ASoP (X^2=15.26, df=1, P<0.001) (Table 2).

The frequency of diurnal raptors with elevated BLL (>10 µg/dL) at BMW was significantly higher during the big game / coyote hunting period (Oct. 1 -Mar. 31) than during the non-hunting period (Apr. 1-Sept. 30) (X^2=10.62, df=1, P=0.001). The highest frequency of birds sampled with elevated BLL at BMW occurred from December – March (Fig. 3). Conversely, we found no difference in frequency of elevated BLL for diurnal raptors sampled at ASoP across these same time periods (X^2=0.05, df=1, P=0.83). This seasonal pattern was not influenced by sampling effort, which was variable throughout the year and actually highest during the summer months when birds with elevated BLL were at their lowest at both sites (Fig.

Table 2. Blood Lead Level results at each care center.

	Audubon Society of Portland				Blue Mountain Wildlife				
	Blood Lead Level (µg/dL)				Blood Lead Level (µg/dL)				
	<10	>10-20	>20-50	>50	<10	>10-20	>20-50	>50	**TOTAL**
Diurnal raptors	**118**	**1**	**3**	**2**	**102**	**14**	**7**	**7**	**254**
Owl	**77**	**1**	**0**	**0**	**Not sampled**				**78**
Turkey Vulture	**6**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**7**
Common Raven	**Not sampled**				**1**	**0**	**0**	**0**	**1**
TOTAL	**201**	**2**	**3**	**2**	**103**	**14**	**7**	**8**	**340**

3).

Sex of 108 sampled diurnal raptors was estimated (from weight) across both care centers (Males=64, Female=44). We found no difference in frequency of elevated BLL between sexes (X^2=0.04, df=1, P=0.84). We were able to determine the age of 119 diurnal raptors as "adult" or "hatch year." As with sex, we found no difference in the frequency of elevated BLL between these age classes.

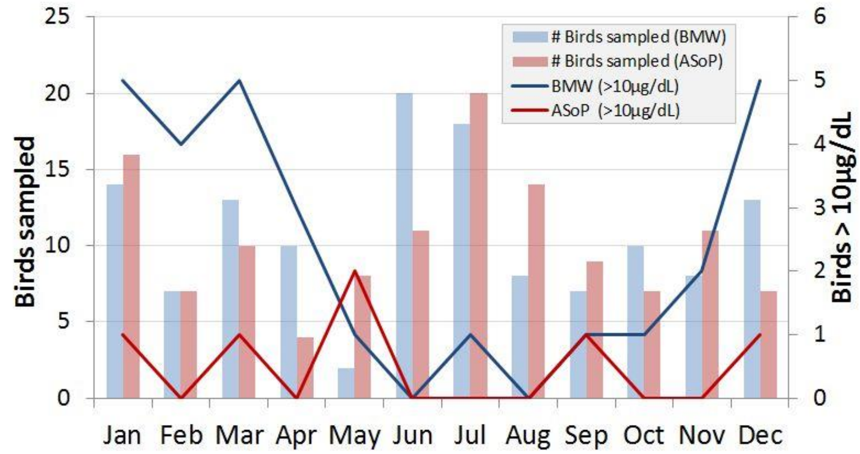


Figure 3. Total number of diurnal raptors (eagles, hawks, falcons) sampled ("bars") and number with blood lead level beyond background range (> 10 µg/dL; "lines") at both study sites. Birds sampled at BMW for 3 years (2010-13) and one year (2013) at ASoP.

Only one bird (Bald Eagle) out of seven (16.7%) at ASoP with greater than background "exposure" levels had evidence of radiopaque matter in the gastrointestinal tract (Fig. 4). This is noteworthy because radiography is routinely used to make a tentative diagnosis of lead toxicity. In our assessment of clinical signs in birds with elevated BLL, we found no relationship. Even birds with extremely high blood lead levels (n=2) did not show signs of lead toxicity.

Figure 4. Radiograph of Bald Eagle 633-13. Lead fragments are visible in yellow circle.

Discussion

Although many studies have examined lead poisoning in wildlife, this study is unique in its comparison of BLL in avian scavengers from an urban/suburban matrix versus nearby rural populations. As predicted, diurnal raptors sampled from rural areas had higher lead levels than those from urban / suburban areas.

We also documented higher levels of lead seasonally (late winter – early spring) in the birds collected from rural areas. This time frame corresponds with the big game hunting season (http://www.dfw.state.or.us) and peak coyote hunts (Stauber et al.

2010) in the Pacific Northwest. Anecdotal evidence also points to "varmint" hunting for smaller animals like Ground Squirrels and Jackrabbits to be another source of lead poisoning in some of the birds sampled (at BMW).

Our findings reflect those of other studies that have examined seasonal patterns in lead poisoning in avian scavengers. Cruz-Martin et al. (2012) documented significantly elevated levels of lead in Bald Eagles in the Midwest during the late fall-early winter period (deer hunting season). In Wyoming, Craighead and Bedrosian (2008) found that Common Ravens tested during the hunting season had significantly elevated BLL compared to the non-hunting season. Kelly and Johnson (2011) found that lead exposure in Turkey Vultures was significantly higher during the deer hunting season compared to the off-season in California. Similar to our study, Stauber et al. (2010) documented that Golden Eagles and Bald Eagles admitted to rehabilitation centers in the Pacific Northwest had significantly higher elevated lead levels during the big game hunting season. Our study thus adds to a growing body of evidence indicating that lead from carcasses of animals killed by hunters is the primary source of lead poisoning for avian scavengers.

However, there are exceptions to this rule. A Red-tailed Hawk recovered by the ASoP from downtown Portland had a moderately elevated BLL (21.7 µg/dL). This bird was a fledgling, so we know it did not move from another location and its parents likely did not travel outside of the urban grid to forage (based on breeding territory size in Oregon; ~2.3 km^2; Janes 1984). It is not clear how this individual became contaminated.

In this project, we assumed that birds with elevated lead contracted it near the site of recovery. Of course, birds are highly mobile so this may not always have been true. However, most birds with elevated lead were recovered outside of the core migration season (Poole 2005), presumably while on their wintering grounds. Also, lead levels in blood decline over approximately two weeks, returning to background levels (Fry 2003). Based on these facts, we feel reasonably confident the elevated lead levels in these birds occurred from consuming lead-contaminated carcasses in the areas from which they were recovered.

Golden Eagles were sampled only at Blue Mountain Wildlife. A significant proportion had elevated lead levels (Photo: Don Baccus).

None of the birds at ASoP with elevated BLL showed any clinical signs indicative of lead poisoning. This is notable because without testing blood lead levels, lead-poisoned birds could be misdiagnosed or most likely underdiagnosed. Typical signs of lead toxicity in birds include weakness, altered mentation, lack of appetite, paralysis of the legs, circling, tremors of the body and head, droopy posture, seizures, blindness, excessive thirst or droppings, regurgitation, weight loss, blood in the droppings, pale color of mucous membranes due to anemia, and dark coloring to the droppings or excessively wet droppings (Rattner et al. 2008). We did not observe any of these signs.

Radiographic evidence of lead fragments also failed to reveal the majority of instances of lead poisoning determined from blood testing. Other researchers have previously documented that radiographic evidence of lead fragments, particularly in raptors, is often absent in lead-poisoned birds (Stauber et al. 2010, www.hsvma.org). This emphasizes the fact that testing of blood (or other tissues) is a necessity in order to properly diagnose lead poisoning.

It is important to point out that we had low sample sizes for birds with elevated BLL at ASoP. Therefore our conclusions, particularly those indicating a lack of relationship between clinical signs / radiography with detectability of lead toxicity, must be viewed cautiously.

In summary, this study lends further support to the observation that lead in the environment poses a danger to avian scavengers that consume lead-contaminated carcasses and gut piles. We intend to continue this project for at least two more years to bolster our sample sizes and potentially to include birds lead-tested at additional wildlife rehabilitation centers in the region. However, the weight of evidence so far clearly indicates that a lead ammunition ban should be considered in Oregon. Alternatives to lead ammunition for big game hunting are available. In 1991, lead ammunition was banned for waterfowl hunting across the U.S. The transition to non-lead ammunition went smoothly, and studies indicate (e.g. Anderson et al. 2000) that millions of birds have been spared death due to lead poisoning since that time.

Red-tailed Hawks were the most frequently sampled raptor at both care centers. Photo: S. Carpenter.

Acknowledgments
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Appendix. List of 47 clinical signs examined for in lead-tested birds at ASoP.

Weight • Underweight • Normal weight • Overweight	Integumentary • External parasites • Wounds • Bruising • Oil	Cardiovascular • Tachycardia • Bradycardia • Hypovolemia • Shock • Hemorrhage
General • BAR (bright, alert, responsive) • QAR (quiet, alert, responsive) • Dull • Recumbent (i.e. lying down) • Obtunded • Weak • Dehydrated • Stupor	Musculoskeletal • Fracture • Luxation • Amputation Respiratory • Upper airway pathology • Lower airway pathology • Dyspnea	Nervous • Ataxia (loss of coordination of muscles, esp. extremities) • Paresis (partial motor paralysis) • Paralysis (loss or impairment of voluntary movement in a body part) • Tremors (involuntary shaking of body or limbs) • Seizures • Head tilt • Circling • Stunned (i.e. head injury) • Torticollis
Infection • Pox • other	Ocular injury • Chronic • Acute	
Ophthalmologic • Chronic injury • Acute injury • Infection • Nystagmus	Gastrointestinal • Vomiting/regurgitation • Internal parasites • Green stained feces • Impaction or ileus	