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Lead Concentrations of White-winged Doves, *Zenaida asiatica* L., Collected in the Lower Rio Grande Valley of Texas, USA

Alan M. Fedynich · Timothy B. Fredricks · Steve Benn

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Abstract White-winged dove (*Zenaida asiatica* L.) exposure to environmentally accessible lead is a management concern. Detectable concentrations of lead were found in 142 (66%) of 214 white-winged doves collected in 2002 and 2003 at two wildlife management units in South Texas. Mean ± SD lead concentration was 0.70 ± 1.10 μg/g dry weight and ranged from ND to 11.01 μg/g dw. Lead concentrations were significantly lower in the 2002 samples, but similar between management units, age, and gender. White-winged doves in South Texas are being exposed to lead in the environment with some reaching subclinical to toxic levels.

Keywords Contaminant · Lead · White-winged dove · *Zenaida asiatica*

Lead (Pb) is a toxic element found naturally within the environment, but is redistributed and often concentrated locally as the result of various anthropogenic activities. Consequently, there is worldwide concern about the negative impact of lead on biological systems (Rattner et al. 2008). In birds, acute lead toxicity often results in morbidity and mortality, while chronic, sub-acute levels have been linked to reduced egg hatchability (Buerger et al. 1986), decreased egg production and increased number of soft-shelled eggs (Stone and Soars 1974), reduced production of spermatozoa (Kendall and Scanlon 1981), and impaired immune system (Grasman and Scanlon 1995). Such impacts on breeding individuals could have a negative influence at the population level.

There is growing concern that managed dove hunting areas, in which cultivated grain crops are specifically planted to attract doves to the same sites where they are hunted, pose increased risks to doves from accidental lead shot ingestion (Schulz et al. 2002). Substantial increases in the density of lead pellets between pre- and post-hunting seasons have been found on areas traditionally managed for hunting mourning doves (*Zenaida macoura*) (Lewis and Legler 1968; Schulz et al. 2002). Several public hunting areas in the Lower Rio Grande Valley (LRGV) of Texas are specifically managed for white-winged doves (*Zenaida asiatica* L.; WWD) and mourning doves, which include growing grain crops during spring and summer and allowing hunting on the harvested fields beginning the first weekend in September.

Fredricks et al. (2009) examined 70 adult WWDs collected in the LRGV during summer 2003 for environmental contaminants and found none had detectable levels of lead, even though collection areas included two managed dove fields. Based on their findings, it is possible that WWDs were not being exposed to spent lead shot on the management areas during summer (or elsewhere within the LRGV) or lead-contaminated WWDs were no longer present in the summer WWD population. To learn more about the possibility of lead contamination in this species, we evaluated lead liver concentrations of hunter-shot

A. M. Fedynich (✉) · T. B. Fredricks
Caesar Kleberg Wildlife Research Institute, Texas A&M University-Kingsville, 700 University Boulevard, MSC 218, Kingsville, TX 78363, USA
e-mail: alan.fedynich@tamuk.edu

S. Benn
Texas Parks and Wildlife Department, 410 North 13th St., Edinburg, TX 78539, USA

Present Address:
T. B. Fredricks
Bayer CropScience, Ecotoxicology, 17745 South Metcalf, Stilwell, KS 66085, USA

WWDs collected from two managed dove hunting units in the LRGV during the special WWD season in 2002 and 2003.

Materials and Methods

The Anacua Unit (26°03′55″ N, 97°50′36″ W) and Resaca de la Palma Unit (25°59′58″ N, 97°34′19″ W) within the Las Palomas Wildlife Management Area in Cameron County, Texas, USA (Fig. 1) were selected for study because they have been managed for WWD by the Wildlife Division of Texas Parks and Wildlife Department (the Resaca de la Palma Unit is now managed by the State Parks Division; hunting is now limited to a few days per season). The study areas are approximately 30 km apart (Fig. 1). Both units require hunters to check in during the special WWD season (first two weekends in September) and allow lead shot for hunting upland and migratory gamebirds. The Anacua Unit has designated dove hunting areas in the north and south sections of the unit and has a hunter check station.

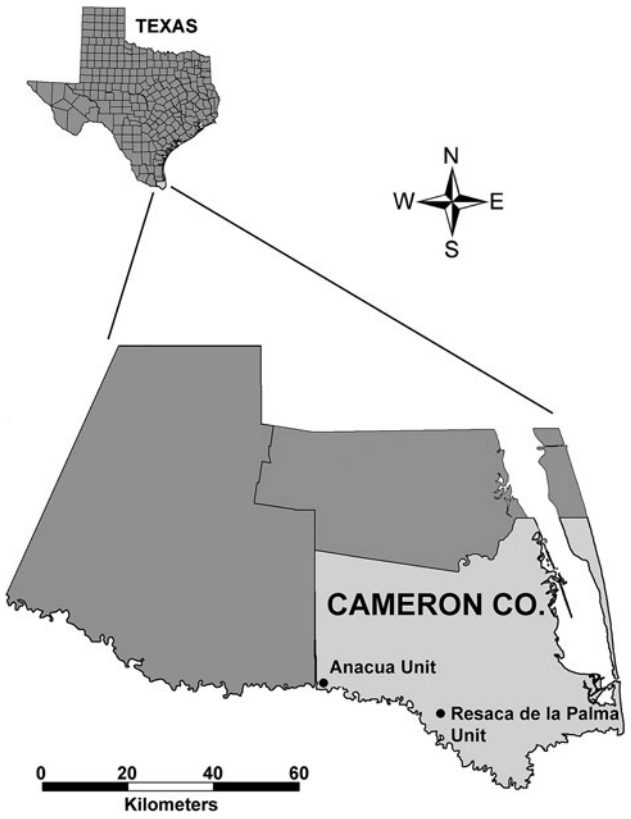

Fig. 1 Locations of the Anacua and Resaca de la Palma units on the Las Palomas Wildlife Management Area in the Lower Rio Grande Valley of Texas, USA

Liver samples were obtained from hunter-shot WWDs on 7 September 2002 and 6 September 2003. Samples in 2002 were obtained from hunters that were using lead shot. The WWDs sampled in 2003 were collected from hunters using non-toxic steel shot to avoid the possibility of liver tissue contamination from using lead shot.

In the field, WWD age and gender were determined by external plumage characteristics and inspection of gonads, respectively. Livers were removed (those with pellet perforations were not used), placed in pre-cleaned sample vials, frozen, and shipped to The Institute of Environmental and Human Health, Division of Environmental Health and Toxicology, Texas Tech University Health Sciences Center for analysis.

Livers were oven dried at 100°C for 48 h and weighed (±0.1 mg); approximately 1 g wet weight (ww) was removed and digested individually in 10–15 ml of concentrated nitric acid followed by 1–2 ml of 30% hydrogen peroxide and diluted to volume with deionized water. Samples were tested using a Perkin Elmer© AAnalyst 600 Graphite Furnace-Atomic Absorption Spectrometer (GF-AAS) and a Leeman Labs Inc. DRE ICP-AES. Standard curves were established for 5, 10, 20, 50, 100 ppb lead (GF-AAS) and 25, 50, 100, 200, 400 ppb lead (ICP-AES). The method detection limit for GF-AAS was 67.8 ng lead/g dry weight (dw) and for ICP-AES 681 ng lead/g dw. Standard curves had coefficient of determination values of at least 0.9985. Check standards were analyzed every 10 samples and if different by more than ±15% a full standard curve was reanalyzed prior to continuing with sample analyses.

To include sample values below the method detection limit in summary data and statistical comparisons, a random number generator assigned values between 0 and the detection limit for those samples that were below the detection limit (Heisel 1990). Lead values are presented as μg lead per 1 g liver dw. Descriptive statistics are reported as arithmetic mean with standard deviation. To compare lead liver concentrations from studies presenting ww values, conversion of their ww values to dw is based on the assumption that ww moisture content of liver is approximately 70% (Ohlendorf et al. 1986).

Statistical analyses were performed using SAS Version 9.1. Chi-square analysis was used to assess the proportion of WWDs below the detection limit between study units within years. Distribution of the independent variable lead concentration in dried liver tissues was tested for normality and, if necessary, log + 1 transformed. Analysis of variance was used to determine if mean lead concentrations varied by the main and interaction effects of year (2002, 2003), management unit (Anacua Unit, Resaca de la Palma Unit), WWD age (juvenile, adult), and WWD gender (male, female). Statistical significance was inferred at $p \leq 0.05$.

Results and Discussion

Two hundred fourteen WWD liver samples were collected and examined for lead residues, of which 77 (representing 27 juvenile males, 18 juvenile females, 18 adult males, 14 adult females) were collected in 2002 and 137 (representing 45 juvenile males, 43 juvenile females, 22 adult males, 27 adult females) were collected in 2003. Of the 214 WWDs, 142 (66%) had detectable concentrations of lead (Table 1). The number of WWD samples below the detection limit in 2002 and 2003 was 31% and 9%, respectively. The proportion of WWD samples below the detection limit varied ($p = 0.0001$) between management units during 2002, in which there were proportionally more WWD from the Resaca de la Palma Unit (50%) than the Anacua Unit (3%) below the detection limit. In the 2003 samples, no differences ($p = 0.87$) between management units were observed in the proportions (8%, Anacua Unit; 9%, Resaca de la Palma Unit) of WWDs below the detection limit.

Overall mean lead concentration was 0.70 (standard deviation [SD] = 1.10) μg/g and ranged from ND–11.01 μg/g (Table 1). Mean lead concentrations varied ($F = 72.01$, $p = 0.0001$) between years, in which WWDs sampled in 2002 had lower lead concentrations (0.16 μg/g, SD = 0.49) than those sampled in 2003 (0.99 μg/g, SD = 1.23). WWDs sampled in 2002 and 2003 ranged from ND–3.82 μg/g and ND–11.01 μg/g, respectively (Table 1). No significant differences were found in mean lead concentrations between WWD age ($F = 1.72$, $p = 0.19$), WWD gender ($F = 0.61$, $p = 0.44$), or management units ($F = 0.30$, $p = 0.58$).

The present study found that WWDs occurring in the LRGV are being exposed to lead within the environment, in which 66% sampled had detectable concentrations. This represents the first documented report of WWDs with lead occurring in the LRGV. Lead contamination of 66% is comparable to studies using hunter-shot mourning doves, which range from 64–95% (Locke and Bagley 1967; Kendall and Scanlon 1979). It should be noted that the earlier studies were conducted when leaded gasoline was routinely sold in the US and exposure of mourning doves could have occurred when they ingested lead-contaminated grit along roadways.

Franson (1996) summarized lead liver values from the literature for columbids and reported that 2–6 ppm ww (2.9–8.6 μg/g dw) was considered subclinical, >6 ppm ww (8.6 μg/g dw) was toxic, and >20 ppm ww (>28.6 μg/g dw) resulted in death. Based on these criteria, one WWD had a toxic concentration (11.0 μg/g dw) and five had subclinical concentrations (3.3, 3.3, 3.8, 4.1, 7.1 μg/g dw), suggesting that at least some individual WWDs likely succumb to lead toxicosis. All six WWDs were collected at the Resaca de la Palma Unit, representing 4.9% of the Resaca de la Palma Unit total sample and 6.4% of the WWDs with detectable concentrations collected from the Resaca de la Palma Unit. These values compare to studies examining mourning doves, which reported 5–8% had elevated lead liver concentrations (Kendall and Scanlon 1979; Best et al. 1992). No WWDs were found to have lead concentrations sufficient to cause death (≥28.6 μg/g dw), however, it should be noted that hunter-shot birds are those still capable of flight (Schulz et al. 2002). Consequently, WWDs too intoxicated to fly are not represented in the sample. Based on a lead pellet dosing study with mourning doves, death can occur as early as 2 days, depending on dose, with 97% of the mortalities occurring within 11 days post-ingestion (Buerger et al. 1986). It is likely that WWDs experiencing acute lead poisoning share a similar fate.

Differences in lead concentrations between years suggest variability in acquisition or survival. It is possible that different fields within the management areas are being used by WWDs in which the exposure probability to lead varies. Using lead shot to collect WWDs during 2002 and steel shot during 2003 did not appear to be a bias, since the lead concentrations in WWD liver tissues tended to be lower during 2002 than 2003 with a substantial number of non-detections occurring in 2002 (31% versus 9%, respectively).

Although WWDs were collected on the Anacua Unit and Resaca de la Palma Unit, it is uncertain whether lead

Table 1 Lead concentrations (μg/g dw) in liver from 214 white-winged doves collected on the Anacua and Resaca de la Palma units of the Las Palomas Wildlife Management Area in the Lower Rio Grande Valley of Texas during September 2002 and 2003

Collection sites	2002				2003				Total			
	n	$\bar{x}$	SD	Range	*n*	$\bar{x}$	SD	Range	*n*	$\bar{x}$	SD	Range
Anacua	31	0.20	0.36	1 ND–2.08	60	0.81	0.59	5 ND–2.04	91	0.61	0.60	6 ND–2.08
Resaca de la Palma	46	0.13	0.57	23 ND–3.82	77	1.14	1.55	7 ND–11.01	123	0.76	1.36	30 ND–11.01
Total	77	0.16[A]	0.49	24 ND–3.82	137	0.99[B]	1.23	12 ND–11.01	214	0.70	1.10	36 ND–11.01

ND nondetectable and below detection limit samples

[A,B] Means were significantly different ($p \leq 0.05$)

was acquired on the management units or elsewhere. However, lead concentrations found in juvenile WWD before their first fall migration to Mexico and Central America indicate acquisition within the region. Findings from studies focusing on mourning dove public hunting areas have found substantial increases in lead shot in the upper soil profile that raises the exposure probability of birds feeding in the same fields that they are being hunted (Castrale 1989; Schulz et al. 2002). Evidence of lead accumulation from these studies points to a need to determine lead pellet densities on managed dove fields at the Anacua Unit and Resaca de la Palma Unit.

Besides the negative impacts of lead on WWDs, lead accumulation also affects the food web. The dissolution of lead by geochemical processes allows lead to be incorporated into various compounds and complexes (Rattner et al. 2008) thereby facilitating bioaccumulation. Additionally, lead contaminated prey can have important implications for predators and scavengers, particularly threatened and endangered species (Rattner et al. 2008). Two endangered species, the ocelot (*Leopardus pardalis*) and jaguarundi (*Herpailurus yagouaroundi*) occur within the LRGV and northern Mexico, but have not been found on the study sites. However, the Rio Grande River along the Texas-Mexico border serves as a wildlife travel corridor (Tewes and Blanton 1998), which bounds the southern border of the Anacua Unit and is within 5 km from the Resaca de la Palma Unit.

Based on the present study's findings, WWDs occurring within the LRGV are being exposed to lead within the environment, and points to the need for additional studies to access the availability of spent lead shot within the soil feeding zone of WWDs. Additionally, further research should focus on bioaccumulation of lead in the fauna and flora within the LRGV, particularly on wildlife management areas that have dove hunting fields.

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