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# Detection of Zinc, Lead, Cadmium and Arsenic in Dabbling Ducks from Durango, Mexico

M.E. Pereda-Solis, J.H. Martínez-Guerrero and J.A. Toca-Ramirez
Facultad de Medicina Veterinariay Zootecnia, Universidad Juarez del Estado de Durango, México

*Corresponding Author: Jose H. Martínez-Guerrero, Facultad de Medicina Veterinariay Zootecnia, Universidad Juarez del Estado de Durango. Km 11.5 Carretera Durango-Mezquital, Durango, Dgo. 34000, México Tel/Fax: 618.8.18.99.32*

## ABSTRACT

Zn, Pb, Cd and As were determined by atomic absorption spectrophotometry in liver of waterfowl wintering or inhabiting a wetland flooded by effluents from a waste water treatment plant near the city of Durango, Mexico. The current study attempted to determine the concentrations of these trace elements in dabbling ducks and evaluate the potential negative effects on their health. Zn, Pb, Cd and As were found in all liver samples. Statistical analyses demonstrated that Northern Shoveler (*Anas clypeata*) displayed higher levels of Zn (Kruskal-Wallis test $p<0.05$) than blue-winged teal. Pb concentrations showed less variation than the other metals (SE = 0.14). Green winged teal (*Anas crecca*) had significantly higher levels (Kruskal-Wallis test $p<0.05$) of Pb than northern shoveler. The maximum level of Pb = 4.71 ppm DW, was below concentrations know to be lethal to waterfowl. All waterfowl had similar Cd concentrations in liver samples (Kruskal-Wallis test $p>0.05$). The observed average was 2.66 ppm DW. As concentration in liver of blue-winged teal (*Anas discors*) were significantly higher (Kruskal-Wallis test $p<0.05$) than northern shoveler. The mean concentration was 4.76 ppm DW, with some outlier values up to 3.3 ppm w/w in individuals of gadwall (*Anas strepera*). We found no evidence of potential lethal or sub lethal effects based on the concentration of this metals and metalloids in the liver of dabbling ducks.

**Key words:** Zinc, lead, cadmium, arsenic, dabbling ducks

## INTRODUCTION

Environmental pollution is a global problem posing serious risk to man and wildlife. The technology development and the industry are among the foremost factors for environmental pollution (Rajaganapathy *et al*., 2011). Heavy metals and metalloids are an increasing environmental problem worldwide as result of this development (Kalantari *et al*., 2006). Many kinds of potentially harmful chemicals are found in aquatic environments used by waterfowl. Some chemicals, such as metals and metalloids, may become environmental contaminants trough their use and application (Cheraghi *et al*., 2009). Considering different types of aquatic pollution, heavy metal pollution is less visible but its effects on the ecosystem can be intensive and more extensive (Christopher *et al*., 2009). The life of aquatic organisms is in risk when the heavy metals concentration rise above the natural background in water, sediment and the food supply (Ghosh and Adhikari, 2006). Metals and metalloids may cause direct poisoning and death but they also may have adverse effects in behavior, survival, reproduction, survival of young and impairment of the immune system.

The diagnosis of chemical poisoning as the cause of wildlife mortality is a challenging task because: (a) The different biological responses after concurrent exposure to multiple chemicals, (b) The absence of tissue residues for some chemical toxins and (c) The lack of specific pathological changes associated with most chemical toxins in organs and tissues (Friend and Franson, 1999).

Zinc is required as trace elements in the diets of animals (Gheisari *et al.*, 2011) but when they occur in relatively high levels, it produce toxic effects (Zare and Ebadi, 2005; Gassaway and Buss, 1972). Zn is essential metal as a result of physiological importance, is normally observed at concentrations higher than other metals and metalloids.

Lead is a poisonous metal and is ubiquitous because of its widespread use in gasoline, batteries, solders, pigments, ammunition and numerous other applications. It has been implicated in inhibiting heme synthesis, decreasing red cell survival and neurological dysfunction with chronic exposure (Kaplan *et al.*, 2011). Poisoning of birds can occur by ingestion of lead shot (Newman, 2010).

Cadmium compounds are present widely in nature and are generally toxic. Concentrations of Cd in fresh waters may reach 1.0 ppm higher than for most other metals (Gochfed and Burger, 1982).

In abundance of elements, arsenic ranks 20th in the earth's crust (1.5-2 mg $kg^{-1}$) (Bose *et al.*, 2011; Woolson, 1975). In aquatic ecosystems like lakes and rivers elevated values are probably due to the presence of industrial sub products and other anthropogenic sources, like smelting and mining, combustion of fossil fuel, arsenical grasshopper baits, synthetic detergent and sewage sludge wastes, arsenical defoliants, herbicides, insecticides, pigments and pesticides (Bose *et al.*, 2011; ALS, 1977). Arsenic concentrations in terrestrial flora and fauna, birds are usually<1 mg $kg^{-1}$ fresh weight (Eisler, 1988). Plants and animals living in naturally arseniferous areas or near anthropogenic sources may contain elevated tissue residues of As (Eisler, 1988).

Some bird species are considered environmental bioindicators because of their abundance, wide distribution, feeding at different trophic levels and their long span of life (Lucia *et al.*, 2010). This leads to consider the aquatic birds as bioindicators of heavy metal contamination in wetlands. (Scheuhammer, 1989). The objective of this study was to determine the concentrations of Zn, Pb, Cd and As in dabbling ducks in a wetland irrigated with effluent from wastewater treatment facilities and evaluate the potential negative effects on their health.

## MATERIALS AND METHODS

**Study site:** This study was performed in the area occupied by the Management Unit for the Conservation of Wildlife (UMA) "Los Alamos" close to the city of Durango, Mexico, (24°05'382 N, 104°30'043"W). The area is flooded by waste water treatment plant of Durango and forms a lake-type wetland. The vegetation consists of shrub layer plants of the genera *Acacia* and *Prosopis* the herbaceous layer of grasses and halophytes those of the genus *Sporobolus*.

**Sample collection:** During the waterfowl hunting season of 2010 and 2011, livers of 33 dabbling ducks, specifically mallard (*Anas platyrhynchos*; n = 5, MALL), green winged teal (*Anas crecca;* n = 2, GWTE), blue-winged teal (*Anas discors*; n = 8, BWTE), northern Shoveler (*Anas clypeata*; n = 15, NSHO) and gadwall (*Anas strepera*; n = 3, GADW) were taken from a wetland irrigated with effluent from wastewater treatment facilities in Durango, Mexico. The birds were weighed; their livers were removed and stored in chemically cleaned jars.

**Metal determination:** Livers were analyzed for zinc, lead, cadmium and arsenic at the Union Ganadera Regional de Durango Laboratory. Each tissue sample was individually homogenized in a blender and dried at 60°C for seven days, then charred in a muffle furnace for 1 h at 600°C. The ash was cooled, dissolved in a mixture of nitric acid and hydrochloric acid over a hot plate. Metal and metalloids concentration were determined with an atomic absorption spectrophotometer brand Varian.

**Statistical analyses:** Statistical analysis was performed using the JMP 9.0.0 program (SAS Institute Inc., 2010) obtaining the main descriptive statistics and box plots for each bird species and chemicals. Shapiro-Wilk test was used to verify normality and homogeneity of variance. The data were not normal; thus statistics nonparametric were applied (Kruskall-Wallis) to compare the average values of the concentrations of metals and metalloids.

## RESULTS AND DISCUSSION

Zinc, lead, cadmium and arsenic were found in all liver samples at different ranges for each element (Table 1). In general, zinc concentrations were higher than for other chemicals and the NSHO had the highest value of 181.56 ppm (dry weight). Less variation was observed in the average lead concentration for all ducks (mean 2.74 ppm, SE = 0.14). The overall mean concentration of cadmium was 2.66 ppm (dry weight) and it was the lower of all measured chemicals. The higher value of arsenic (9.51 ppm DW) was observed in a GADW.

Statistical analyses demonstrated that NSHO displayed higher levels of Zn (Kruskal-Wallis test $p<0.05$) than BWTE, however there were no differences of these two species with the remaining species. The 48% of cases were below the average of Zn concentration (93.95 ppm DW = 35.13 ppm w/w). The mean Zn values found in our study were similar to those reported by De Mendoza *et al.* (2006) who reported 45 ppm Zn w/w in mallards.

In a study by Gassaway and Buss (1972) mallard ducks fed with zinc-supplemented diets containing 3000, 6000, 9000 and 12000 ppm of Zn had concentrations of Zn of 401, 483, 461 and

Table 1: Metal and metalloids concentration in liver of dabbling ducks

| | | Trace elements | | | |
|---|---|---|---|---|---|
| Species | n | Zn | Pb | Cd | As |
| NSHO | 15 | 103.8±6.6$^{a}$ | 2.4±0.1$^{a}$ | 3.6±2.0$^{a}$ | 3.9±0.5$^{a}$ |
| | | (81.2-181.6) | (1.5-3.7) | (0.4-31.9) | (0.5-6.2) |
| MALL | 5 | 109.7±14.1$^{ab}$ | 2.7±0.3$^{ab}$ | 1.5±0.2$^{a}$ | 4.4±0.6$^{abc}$ |
| | | (81.4-156.8) | (1.9-3.8) | (0.8-2.1) | (2.6-6.4) |
| BWTE | 8 | 73.5±12.9$^{b}$ | 2.9±0.4$^{ab}$ | 2.0±0.0$^{a}$ | 6.0±0.4$^{c}$ |
| | | (44.8-146.8) | (1.9-4.7) | (1.6-2.4) | (4.1-8.0) |
| GADW | 3 | 89.1±27.9$^{ab}$ | 3.0±0.4$^{ab}$ | 2.0±0.3$^{a}$ | 6.6±1.7$^{abc}$ |
| | | (44.9-140.8) | (2.0-3.6) | (1.4-2.5) | (3.5-9.5) |
| GWTE | 2 | 70.0±23.7$^{ab}$ | 4.0±0.6$^{b}$ | 2.0±0.0$^{a}$ | 4.4±0.8$^{abc}$ |
| | | (46.4-93.7) | (3.5-4.6) | (2.0-2.0) | (3.6-5.3) |
| Overall mean | | 93.9±5.8 | 2.74±0.1 | 2.7±0.9 | 4.76±0.3 |
| | | (44.8-181.6) | (1.5-4.7) | (0.4-31.9) | (0.5-9.5) |

Geometric means (ppm DW) ranges are in brackets. Values not sharing the same letter (among species) are significantly different, Kruskall-Wallis test ($p<0.05$)

340 ppm w/w, respectively. In this study it is notable that none of the liver samples had concentration higher than 66.80 ppm w/w. Beyer *et al.* (2004) consider that birds regulate Zn effectively within a wide range of exposure.

Lead was detected in 100% of our samples. Pb concentrations showed less variation than the other metals (SE = 0.14). GWTE displayed higher levels (Kruskal-Wallis test $p<0.05$) of Pb than NSHO, there were no differences of these two species with the remaining species. The maximum level of 4.71 ppm DW (1.33 ppm w/w), was below concentrations known to be lethal to waterfowl (King and Cromartie, 1986), also the mean concentration of lead found (2.74 ppm DW = 1.01 ppm w/w) in these birds did not indicate any risk for maintaining homeostasis. Friend and Franson (1999) consider that liver lead values of 6-8 ppm or higher on a w/w basis or 20-30 ppm DW are suggestive of lead poisoning when other signs of lead poisoning are present. Pain (1996) also found that certain functions may be impaired and that external signs of poisoning may occur when hepatic Pb is between 20 and 50 ppm DW.

In this study all ducks collected showed similar Cd concentrations in all liver samples (Kruskal-Wallis test $p>0.05$). The observed average was 2.66 ppm DW (1.08 ppm w/w), also we found an outlier value of 31.9 ppm DW in an individual of NSHO. Several studies on experimental and wild birds provide relevant information, Mora and Anderson (1994) reported similar values in a study with aquatic and wetland birds with liver concentration of 0.7 ppm w/w (*Phalacrocorax auritus*), 0.5 ppm w/w (*Bubulcus ibis*) and 2.1 ppm w/w (*Agelaius phoeniceus*), according to this authors the Cd threshold concentrations for effects in wildlife are relatively high. This is consistent with the research of White and Finley (1978) where adult female mallards fed 200 ppm Cd for 13 weeks accumulated up to 110 ppm w/w of Cd in their livers and stopped egg laying but not other effects were observed. Cain *et al.* (1983) fed Mallard ducklings with 20 ppm for 12 weeks accumulated 42 ppm w/w in the liver and had mild to severe kidney lesions. Cadmium levels observed in birds in our study apparently represent no health risk.

In this study, as concentration in liver of BWTE were significantly higher (Kruskal-Wallis test $p<0.05$) than NSHO. No differences were observed between other species. The mean concentration was 4.76 ppm DW (1.7 ppm w/w), with some outliers values up to 3.3 ppm w/w in individuals of GADW. Our values of As also correspond with the obtained in different kind of raptors where average values were between 1.06 and 5.84 ppm DW, these values seem slightly high but there is not a risk to the survival of the species analyzed (De Mendoza *et al.*, 2006). Also Kunito *et al.* (2008) suggests that birds may have a specific mechanism for accumulating arsenic and osmoregulation in these animals may play a role in the high accumulation of As.

## CONCLUSION

The present study provides a first insight into the contamination with Zn, Pb, Cd and As of waterfowl wintering in the vicinity of the city of Durango, Mexico or possibly just migrating through the area. We found no evidence of potential lethal or sub lethal effects based on the concentration of this metals and metalloids in the liver of dabbling ducks.

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