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Using Feathers as a Biological Indicator of Lead Environmental Pollution

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Abstract: Feather samples of 309 of wild palm dove, *Streptopelia seneglenses* were collected from three different cities of Saudi Arabia; Riyadh, Jeddah and Al-Kharj. These samples were analyzed for lead by atomic absorption spectroscopy. The mean of the lead levels in the feather as a whole were 18.03±1.07, 13.53±0.8 and 2.20±0.41 ppm for the three cities, respectively. The mean of lead levels in the feather quill were 11.61±0.56, 8.20±0.62 and 2.18±0.49 ppm while the levels of lead in the feather vane vexillum were 21.07±1.26, 16.63±1.3 and 1.19±0.47 ppm for the three cities, respectively. In general, the mean lead levels in the feather as a whole in Riyadh were eight times of those in Kharj and 25% higher than those of Jeddah. The results of the present study showed that the feathers of the palm dove contain lead, which may reflect lead contamination in the three cities and confirms the possibility of using feather as a biological monitor for environmental lead exposure in birds and the environment.

Key words: Lead, birds, feather, palm dove, pollution

INTRODUCTION

Lead is still the most commonly reported heavy metal toxicity in both companion and free ranging birds with special concern to birds of prey and pet birds[1,2]. Lead toxicosis is one of the most commonly diagnosed diseases of captive falcons in Saudi Arabia[1]. Birds eat metallic objects that contain lead such as caging objects, paints, solder, batteries, stained glass, shotgun pellets, cable sheathing, steel strips, soils and many other sources that contribute to the contamination of our environment with lead. In addition, contaminants in prey are often biomagnified in hungry migrating birds. Ingested lead enters the gizzard where it is broken down and then absorbed into the blood stream. Birds that eat lead will become ill while those ingest large amounts of lead over a short period of time may suddenly die without any signs of toxicity. Physical, behavioral, neurological, gastrointestinal and hematological clinical signs are seen in lead toxicated birds and may lead to fatally if not treated promptly[2].

Blood has been traditionally used for lead determination as an indicator of lead toxicosis. However, there are several problems with lead blood measurement. Lead has very short biological half life (30-40 days) in blood which therefore, can only be used to monitor the immediate exposure. In addition, blood lead concentration in blood is also affected by the physiological conditions of the bird.

Little is known of feather lead analysis in national and international scientific publication. Hence, an attempt was being made in this study to use feathers as a biological indicator of lead environmental pollution in the palm dove, *Streptopelia seneglenses*.

MATERIALS AND METHODS

Sample collection: Feather samples of 309 of wild palm dove, *Streptopelia seneglenses* were collected from three different cities of Saudi Arabia; Riyadh (the capital city of Saudi Arabia), Jeddah (the main seaport of Saudi Arabia) and Kharj (85 km south of Riyadh; a population of around 150.000) using walk-in traps during January and February 2004. Six outer primary feathers were taken from the right and left wing equally of each bird. Each sample was placed in a plastic sealable container before being transferred to the laboratory.

Sample washing and drying: Feather samples were washed by high purity acetone with mechanical shaking followed by another wash with deionized water. The washed samples by then were dried at 60°C.

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Sample digestion: The collected feathers of each bird were divided into three parts: The first part composed of whole complete primary feathers, the second part consisted only of mixed quills of the primary feathers while the third part was only mixed of the vane vexillum of the same feathers. Each part was treated as a separate sample for lead determination. One hundred milligrams of each sample was digested in 5 mL of 20% HNO_3 for 5 h and by then evaporated to dryness at 85-90°C for over night. The dried residue of each sample was dissolved in 10 mL of 0.1% HNO_3 and was subsequently diluted in deionized water.

Lead determination: Lead was determined in the analyzed solution of each sample by electro-thermal AAS standard technique. All concentrations were expressed in parts per million (ppm = $\mu g\ g^{-1}$).

RESULTS

In Riyadh city lead concentration in the feather as a whole ranged from 35.73 to 1.8 ppm with a mean of 18.03±1.07 ppm, while the levels of lead concentration in Vane vexillum were between 42.8 and 3.2 ppm with a mean of 21.07±1.26 ppm, whereas the levels of lead concentration in the feather quill ranged from 33.16 to 0.9 ppm with a mean of 11.61±0.56 ppm, (Table 1).

In Jeddah city lead concentration in the feather as a whole ranged from 27.9 to 1.01 ppm with a mean of 13.53±0.8 ppm, while the levels of lead concentration in Vane vexillum were between 42.8 and 1.25 ppm with a mean of 16.63±1.3 ppm, whereas the levels of lead concentration in the feather quill ranged from 28.42 to 0.89 ppm with a mean of 8.20±0.63 (Table 1).

In Kharj city lead concentration in the feather as a whole ranged from 4.20 to 0.5 ppm with a mean of 2.20±0.41 ppm, whilst the levels of lead concentration in Vane vexillum were between 2.19 and 0.18 ppm with a mean of 5.75±0.48 ppm, whereas the levels of lead concentration in the feather quill ranged from 3.97 to 0.23 ppm with a mean of 1.19±0.49, (Table 1).

Table 1 also shows that the mean lead concentration of Riyadh city is the highest while Kharej city is the lowest. It also shows that the mean lead levels as a whole feather in Riyadh city is more than eight times of those in Kharej and about 25% higher than those of Jeddah. It can also be seen that the mean of lead concentration in the feather quill in Riyadh was 5.3 times of those in Kharj and 29% higher than those of Jeddah while the levels of lead in the feather vane vexillum in Riyadh city were 17.7 times of those of Kharj city and about 27% higher than those of Jeddah city.

Table 1: Mean SE lead concentration in the feather parts of 309 of wild palm dove, *Streptopelia senegalensis* in the three cities of Saudi Arabia

Feather parts	Riyadh (n:103)	Jeddah (n:101)	Kharj (n:105)
Quill	11.61±0.56	8.20±0.63	2.18±0.49
Vane vexillum	21.07±1.26	16.63±1.30	1.19±0.47
Complete feather	18.03±1.07	13.53±0.80	2.20±0.41

DISCUSSION

Lead is being released into the environment from many sources as a result of wide spread use of chemical and human activities and became one of the most serious pollutants posing dangerous health hazards to man and other creatures. Several reports indicated that the birds and different ecosystems in Saudi Arabia are contaminated with lead. The blood lead concentration of 96 falcons admitted for treatment of lead toxicosis at the Falcon Medical Research Hospital of the Fahad bin Sultan Falcon Center ranged from 0.25 to 0.65 ppm[1]. Environmental studies showed that the dust, soil and waters in Saudi Arabia contain variable amount of lead; the inhalable lead particles in the ambient atmosphere in Riyadh city showed an mean concentration of lead during the work day as 4.37-5.83 $\mu g\ m^{-3}$, which is about twice the international standards[3], while the lead level in the ambient atmosphere in Riyadh city in 1998 varied from 0.031 to 0.208 $\mu g\ m^{-3}$. The lead concentration values obtained for the ambient air in Jeddah city ranged from 0.19 to 1.27 $\mu g\ m^{-3}$[4]. Dammam sewage outfall, lead content was 10 $\mu g\ g^{-1}$ with corresponding values of lead for the shrimps and crabs were 0.73 and 1.32 $\mu g\ g^{-1}$, respectively with a mean of 76 ng L^{-1} in the coastal waters of the Gulf and Western Arabian Sea[5].

The palm dove feeds on seed, grasses and herbs and is seen scavenging on rubbish dumps[6]. The results of the present study showed that the feathers of this wild bird in Riyadh, Jeddah and Kharj contain a considerable lead concentration with a mean of 18.03±1.07, 13.53±0.80 and 2.2±0.41 ppm for the three cities, respectively. This is considered to be high in comparison with the mean feather levels reached by herring gulls in the wild in the northeastern United States that range from 0.5 to 8.5 ppm[7-9]. The results of the present work may indicate that the dust and the garden soil in Riyadh city are more polluted than those in Jeddah and Kharj city. However, the mean of lead concentration in the feathers of Palm dove in Jeddah and Kharj considered to be high. In addition, these results may reflect the huge increase in vehicle numbers and industrial plants in the three cities and their surrounding areas as a result of the progressive growth of the cities and the rapid increase in their

population. Furthermore, the present finding indicates that lead is a potential threat to birds in Saudi Arabia and supports the findings of other investigators with similar indication[1,2]. Lead pellets are often found in the gizzards of many lead poisoned birds in Saudi Arabia. The United States and Canada banned the use of lead shots[10], which is still allowed for hunting in many countries including Saudi Arabia.

The level of blood lead considered toxic but sub-lethal is 0.5 ppm. At level of 0.5 ppm, toxicated waterfowl showed significant depression of delta-aminolevulinic acid dehydratase (ALDAD) activity. In one study, blood lead concentration in the sandhill cranes (*Grus canadensis*) ranged from 1.46-3.78 ppm and in the trumpeter swans (*Cygnus buccinator*) with a mean of 4.0 ppm[11,12]. In other studies, the rough-legged hawks, red-tailed hawks, golden eagles and turkey vultures developed clinical signs of lead toxicosis at a mean blood concentration of 6.7 ppm with reference range of 5.4-8 ppm[13]. The mallard ducks (*Anas platyrhnchos*) died at blood concentration of 8.6-13.9 ppm[14], while the captive falcons in Saudi Arabia showed subtle clinical signs with blood lead concentration as low as 0.2-0.3 ppm[1]. A number of studies have determined lead in birds by utilizing different tissues such as the liver, kidney, brain, heart, muscle and bone[15,16].

Blood, head hair and nail have been traditional specimens as biological indicators to lead determination in human[17,18]. Birds are ideal as models for lead toxicity because they rely on visual and vocal communication, a trait they share with human, whereas rodents rely largely on tactile, olfactory and ultrasonic modes of communication[15,16]. In birds, blood and other tissues are used for lead determination. The use of blood samples has several problems concerning the accuracy and precision of the analytical methods. In addition, blood usage for lead concentration poses problems in terms of collection, preparation and storage. In contrast feather is an ideal tool for sampling and testing. It can be obtained easily, painlessly and can be sent to the laboratory without special handling requirements. Also, feather can be used as an indicator for both acute and chronic lead exposure since lead is stored in the feather months after digestion and can reflect metabolic changes of the body over long period of time due external and internal conditions. Following 30-40 days of an acute lead poisoning, elevated serum level of lead may be undetectable due to the removal of the lead from the serum as protective measure and depositing the metal in other parts of the body.

Lead is accumulated in different organs of the bird but affected by sex and the physiological conditions of the bird. Concentration of lead in the wing bones of laying hens proved to be 4 times higher than levels found in the wing bones of non-lying hens. This may be due to the mobilization of calcium for egg lying increased the absorption of lead from the blood stream.

According to the results of the present investigation, it can be concluded that the lead feathers content of the palm date in Riyadh, Jeddah and Kharj may indicate that the soil and dust of these cities are contaminated with lead in variable levels. In addition, the results of the present study support the use of feathers as an appropriate tool to study lead pollution in birds and the environment. Further works are needed to find a scale that correlate lead concentration in the feather with the lead in blood and other bird tissues such as brain, liver and bone in a hope to determine feather lead concentration at which clinical signs of lead toxicosis are developed.

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