

Survey of Lead in Feathers of Anatidaes from the Pabellon Inlet, Sinaloa, Mexico

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The Anatidaes are a diverse and widely distributed family of aquatic birds, and they constitute an important natural resource due mainly to their abundance and hunting value. Intoxication by lead has been cited as one of the main causes of mortality of Anatidaes in the USA. In the wetlands, during the hunting season, a large amount of lead pellets are accumulated in the soil, and possibly ingested by aquatic birds during feeding. It has been calculated that between 2 to 3% of the total Anatidae population from North America die annually due to lead intoxication (Erlach *et al.* 1988, Friend 1989). The importance of studying lead intoxication in wild birds is highlighted by the high number of dead birds found. This need becomes all the more relevant when one considers that many deaths go unreported due to their occurrence in isolated locations. In addition, the lead acts in non-lethal doses producing diverse physiological disorders that lead to a pathological state in the affected individuals (Bellrose 1980, Danell *et al.* 1988, Friend 1989, Havera *et al.* 1992).

Birds contaminated with lead excrete the metal contained in their blood through their feathers. For some heavy metals, the amount present in feathers tissue reflects the levels of the pollutant in the blood as the feather was growing. The use of the feathers in order to determine the exposure to lead is recommended because they reflect the concentration of pollutant in the blood, they are easy to obtain and manage, and with this collection method there is no need to kill the bird (Appelquist *et al.* 1985, Burger 1993, Furnes *et al.* 1986, Goede and de Bruin 1986).

In Mexico, there are no reports on the exposure of wild birds to lead levels considered harmful. This is mainly due to the fact that few studies have been carried out on intoxication by lead to wild fauna. However, in the state of Yucatan the death of 59 flamingos (*Pheonicopterus ruber*) in 1989 (Schmitz *et al.* 1990) were reported due to lead intoxication. Because the exposure to lead is one of the main problems in the Anatidae environment, the need for evaluating the presence and the effects of lead in the Mexican wetlands is clear. Lead affects the populations of species of great ecological, aesthetic and economic value.

Pabellon inlet is located in the state of Sinaloa, 45 km to the southwest Culiacan

city between 24° 19' and 24° 02' north latitude and 107° 08' and 107° 45' west longitude. The Pabellon has a surface area of 80.000 hectares of wetlands that varies from high salinity on the north side near the connection with the sea, to almost fresh water in the South.

The Pabellon inlet represents a very important feeding point along the aquatic bird migratory route of the Pacific Ocean. This area harbors 19 species of Anatidaes (the 9.4% of the total Anatidaes reported in the area) (Howell and Webb 1995) and therefore represents the second important area for aquatic birds registered in the lacustrine zones of the country. It registers first place in Pintail duck (*Anas acuta*) and the second in green-winged teals (*Ana crecca*). For these species it is one of the most important zones in western Mexico. There are no reports of studies of lead pollution in Sinaloa state, however, the high levels of hunting are a probable source of pollution by this element. There are ten hunting clubs established in the Pabellon inlet, from which the Pichigüila Gun Club, located in the Lagoon of Chiricahueto, has been one of the most active since it was opened in 1970.

Due to the great importance of the area for Anatidaes it is necessary to provide the first measurements of lead concentrations in feathers in Anatidaes from a cross section of the Anatidaes which were shot in the study area.

MATERIALS AND METHODS

A random sample, consisting of 30 individuals from different Anatidae species, was obtained from the hunters that visited the Pichigüila Gun Club, in Culiacan, Sinaloa. The primary feathers 9 and 10 were collected from each individual in order to determine species, sex and age. The feathers were packed in plastic bags in order to avoid possible pollution by external agents and were transported to the laboratory.

All material used was washed with nitric acid at 10%, then washed with Extran, a neutral detergent at 5%. Finally, washed with deionized water and dried in a stove set at 170 °C. All material was covered with plastic wrap to avoid pollution from the environment.

The method of Lodenius and Kuusela (1985), was used for the analysis with few modifications. The feather samples were externally washed with Triton-X 1%, dried in an oven at +50 °C and dissolved in 5 ml of concentrated sulfuric and nitric acid (4:1) for 4 hours in a +60 °C water bath. The lead contents were measured using an atomic absorption spectrophotometer Varian 1275. The detection limit was 0.5 mg/g and the percent recoveries were between 96.5 and 97 %.

RESULTS AND DISCUSSION

The feathers of 30 individuals were analyzed. The sample number was made up of twelve species of the Anatidae family included ten migratory and two resident species. Nineteen species of Anatidae are reported for the study area from which fifteen are migrants from the North (79%) and four (21%) are resident, therefore,

Table 1. Species and number of individuals collected in the Pabellon inlet, Sinaloa, Mexico

Species	Amount	Pb	Feeding	Seasonality
<i>Dendrocygna bicolor</i>	3	-	1a / 1b	R
<i>Dendrocygna autumnalis</i>	3	-	2 / 1b	R
<i>Anser albifrons</i>	1	-	2	M
<i>Anas crecca</i>	3	3	1a	M
<i>Anas acuta</i>	5	1	1 / 2	M
<i>Anas discors</i>	2	2	1a	M
<i>Anas cyanoptera</i>	5	-	1a / 1b	M
<i>Anas clypeata</i>	1	1	1a	M
<i>Anas strepera</i>	1	-	1a / 1b	M
<i>Anas americana</i>	4	1	2 / 1b	M
<i>Aythya valisineria</i>	1	-	1	M
<i>Aythya americana</i>	1	-	1	M

R : Resident ; M : Migratory

Feeding: 1) aquatic plants, 1a) seeds, 1b) stems, leaves, 2) terrestrial gramineous

Table 2. Lead concentrations in the Anatidae from Pabellon inlet, Sinaloa, Mexico

Specie	Sex	Pb (mg/kg)	
<i>A. crecca</i>	immature	254.42	
<i>A. crecca</i>	female	2.75	
<i>A. crecca</i>	male	1.87	
<i>A. discors</i>	male	5.16	
<i>A. discors</i>	female	0.75	
<i>A. clypeata</i>	immature	13.39	
<i>A. acuta</i>	male	10.32	
<i>A. americana</i>	female	8.22	
N	x	s.d.	range
8	37.11	87.91	0.75 -254

this sampling represents approximately the 63.15% of the total number of species (Table 1). The remaining species are not very common in the area.

As it is shown in Table 2, lead was only found in the feathers of eight individuals belonging to five species: *Anas crecca*, *A. americana*, *A. acuta*, *A. clypeata* and *A. discors*, all migratory species.

All species in which lead was detected for this study, feed on seeds of both aquatic plants (*Anas crecca*, *A. clypeata* and *A. discors*) and terrestrial plants (*Anas americana* and *A. acuta*) (Table 2). The highest lead concentrations were found in an immature individual of *Anas crecca* (254.42 mg/kg), whereas the remaining individuals contained concentrations between 0.75 and 13.39 mg/kg. Lead was detected in equal amount in both males and females (Table 2).

The fact that these birds contained lead levels in their feathers is not an indicator of the presence of lead in the study zone, since it is difficult to establish the location in which the birds were exposed to the pollutants. No birds were observed exhibiting the characteristic consistent with behavior lead intoxication, such as erratic flight and difficult landing, loss of flight capability and green feces. All birds sampled showed no morphological signs of lead intoxication.

No differences in concentration between juveniles and adults were detected. The highest concentrations of lead were found in immature individuals (13.39 and 254.42 mg/kg). According to the information available in the literature and the analysis of age of individuals exhibiting lead in feathers reveals that age is not a significant factor. Rattner *et al.* (1989) found that immature individuals of *Anas platyrhynchos* and *Anas rubripes* are less sensitive to lead pollution, due to lead tending to concentrate in bones during the ossification process. Juvenile individuals collected in our study had already finished their bone ossification, although they were not sexually mature.

With respect to heavy metals excretion and molting lead accumulates in feathers during the formation process (Furnes *et al.* 1986). For these species in which lead was detected in the present study, molting takes place between July and August. Lead had to be present in the blood system at the moment of feather formation. This fact indicates that apparently lead was transferred to feathers in the molting period that takes place in the reproductive areas of United States and Canada.

For the present work, lead was found in species which feed on seeds from aquatic plants (*Anas crecca*, *A. clypeata* and *A. discors*) and terrestrial plants (*Anas americana* and *A. acuta*). These results are supported by earlier studies in which the most exposed species to intoxication by lead pellets are those that feed on seeds, since seeds can be confounded with pellets or perhaps pellets are ingested to help to grind food in the gizzard (Eisler 1988, Friend 1989). Another main source of lead could be the lead released to environment by the industrial activity.

Due to the presence of lead residues in any compartment of the environment, it is difficult to determine the origin of lead in migratory birds since the pollutant could be ingested in those areas of reproduction, or during the movement between USA and Canada. It has been indicated on different occasions that chemical pollutants, mainly organochlorine compounds, found in migratory birds originated from Latin America, the wintering area, since the main products found correspond to those not used in both areas (Risebrough *et al.* 1989, Noble and Elliot 1990).

It is important to mention that lead pellets are still being used in Mexico, even though the number of hunters is decreasing, so the available number of pellets for birds to ingest is lower (Carrera 1993). In addition, to the declining use of lead pellets, there have been restrictions enacted in Yucatan, where there were problems related to lead intoxication of flamingos (*Phoenicopterus ruber*) (Schmitz *et al.* 1990).

Considering the obtained results, it is concluded that lead detected in birds during the present study was acquired in the reproduction zones during the molting period. There is probably a relationship between ingestion of seeds and susceptibility to lead accumulation in Anatidae due to feeding habits.

The present report is not decisive in respect to the level of lead toxicity detected. However, this study shows that feathers can be used as an indicator of the lead concentration in birds. Green winged teal (*Anas crecca* Linnaeus) is recommended to be used as a bioindicator in later studies related to detection and exposition of lead in the study area; however, it is necessary to evaluate the utility of other species, such as the blue winged teal (*Anas discors* Linnaeus). The identification of polluted wetlands in Mexico, USA and Canada would allow us to get a better perspective of the problem, and find the possible solutions.

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