Trace Metals in Tissues of Resident and Migratory Birds from a Lagoon Associated with an Agricultural Drainage Basin (SE Gulf of California)

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Abstract. With the aim of knowing Cd, Cu, Fe, Mn, Pb, and Zn concentrations in selected tissues of birds from two places at Altata-Ensenada del Pabellón lagoon in the SE Gulf of California, 39 specimens of 14 species were analyzed. Migratory birds in this study showed the highest values of Cd, Cu, and Pb in liver; Fe and Mn, in viscera; and Zn, in feathers. Concerning the resident avifauna, the highest levels of Cd, Cu, and Fe were detected in the liver, Mn in viscera; and Pb and Zn, in feathers. Regarding Cu and Fe, higher concentrations were detected in migratory avifauna, while Mn and Zn were more accumulated in resident waterfowl. In the case of Cd and Pb, both elements showed a tendency to be more accumulated in resident seabirds. Statistical comparisons showed that in carnivorous and omnivorous birds the resident component was the group with higher levels in more comparisons where mainly Cu and Fe were involved. In the rest of the metals the differences in the concentrations in the distinct tissues of migratory versus resident species were not clearly evident in one group in particular. In a few cases, carnivorous birds had higher levels of Cd than herbivorous and omnivorous birds; for the rest of the metals there was not a clear trend of metal accumulation.

Materials and Methods

Study Area

Altata-Ensenada del Pabellón lagoon is located between 24°20' and 24°40'N and 107°30' and 108°00'W (Figure 1). The weather of the region is from semiarid to arid, with temperatures ranging from 19 to 33.3°C and an annual average precipitation of 673 mm (INEGI 1999). The study area receives waste effluents from intensive agricultural activity (140,000 ha) consisting mostly of vegetable and sugar cane crops (Green-Ruiz and Páez-Osuna 2001). It is known that large amounts of pesticides and fertilizers are used in this region, mainly organophosphorous, carbamates, and metallic fungicides (IAEA 1990).

Field and Laboratory Work

Sampling was conducted under an official permit from SEMARNAP (DOO.O2-3324). Thirty-nine specimens of 14 bird species were obtained from hunters between February and March 2000; biometric data, common names, and feeding habits of analyzed species are provided in Table 1. Glassware and materials used for handling and transportation of samples were thoroughly acid washed to prevent contamination of samples (Moody and Lindstrom 1977). After identification and determination of length and weight of specimens, dissection with a stainless-steel knife was performed in order to obtain heart, liver, muscle, gut (and its contents), and feathers. With the exception of feathers, samples were freeze-dried for 72 h at −45°C and 75 × 10−3 mBar in a Labconco freeze-drying system, then powdered in an automatic agate grinder (Retisch) for 10 min. Powdered samples and feather samples (finely cut) were digested with quartz-distilled concentrated nitric acid in a microwave apparatus (CEM; MDS 2000) under the following conditions: first step, 20 psi for 10 min; second step, 40 psi for 10 min; and third step, 90 psi for 30 min.
These conditions were sufficient to assure the digestion and total dissolution of the tissue aliquots (Ruelas-Inzunza et al. 2000).

Analyses were made by flame atomic absorption spectrophotometry for Cu, Fe, Mn, and Zn; in the case of Cd and Pb, graphite furnace atomic absorption spectrophotometry was used. All determinations were carried out in a Varian SpectrAA 220 spectrophotometer. Levels of the different elements are expressed as micrograms per gram on a dry weight basis. In order to assess the precision of the employed method, reference materials (MA-B-3/TM and SRM 2976) were analyzed (IAEA 1987). Concentrations of analyzed elements were within certified values of reference materials. Percentages of recovery for Cd, Cu, Fe, Mn, Pb, and Zn were 90, 92, 95, 125, 102, and 65%, respectively.

Data Analysis

Data sets were analyzed for normality using the Kolmogorov-Smirnov test and proved to follow a Gaussian distribution. Average metal concentrations in the different tissues of resident and migratory birds of similar feeding habits were compared by Student t test. One-way ANOVA was used to define significant differences among tissues of every species. Statistical analyses were conducted using GraphPad Prism 2.01 (Graph Pad Software Inc., San Diego CA).

Results and Discussion

Considering the distinct tissues, migratory birds in this study showed the highest values of Cd, Cu, and Pb in liver, Fe and Mn in viscera, and Zn in feathers (Table 2). Concerning the resident avifauna, the highest levels of Cd, Cu, and Fe were detected in the liver, Mn in viscera, and Pb and Zn in feathers (Table 3). The sequence of average metal concentrations for migratory and resident birds was Fe > Zn > Cu > Mn > Pb > Cd, with essential metals being at higher levels than nonessential metals.

The main route of entrance of pollutants in wild animals is through food (Szefer and Falandysz 1987) and, depending on the nature of the pollutant, will be the degree of concentration through successive levels in a given trophic chain. Such a