Bull. Environ. Contam. Toxicol. (1989) 43:402–406

Metal Biomonitoring in Bird Eggs: A Critical Experiment

Claudio Leonzio and Alberto Massi

Dipartimento Biologia Ambientale, Università degli Studi di Siena, Via delle Cerchia, 3, 53100 Siena, Italy

Bird eggs have been widely used as an indicator of exposure to persistent contaminants. Recent advances in biomonitoring tend to use multimedia environmental models including wildlife for mass balances of chemicals (Clark et al.,1988) or in a monitor strategy for food quality. For example attempts are being made to monitor the entire Great Lakes basin for the residues of polychlorinated biphenyls and other persistent organic compounds using the eggs of Herring gull (Mineau et al.,1980) and recently the Italian Ministry of Health started a research program on lead and cadmium levels in various agricultural products including hens eggs (Amodio-Cocchieri et al, 1987). Theoretically the high protein and lipid content of the egg binds both polar and apolar chemicals (i.e. metals and chlorinated hydrocarbons). High concentrations of lipophilic contaminants and methylmercury have been described in experimental birds and wild species throughout the world but metals such as cadmium and lead have always been found at natural levels even in the eggs of birds heavily exposed to metals (Hutton et al.,1981; Renzoni et al.,1986; Ohlendorf et al, 1986). These findings pose the question of the relationship between environmental and egg levels of metals. The existence of a metabolic mechanism preventing the tranfer of metals into the eggs would disqualify this as a method of monitoring metals.

The aim of the present paper is to investigate the capacity of bird eggs to reflect the environmental input of inorganic forms of mercury, cadmium and lead so that the validity of this biological sample in environmental studies can be assessed.

MATERIAL AND METHODS

Forty day old female Japanese quail (Coturnix coturnix

Send reprint request to C.Leonzio at the above address.

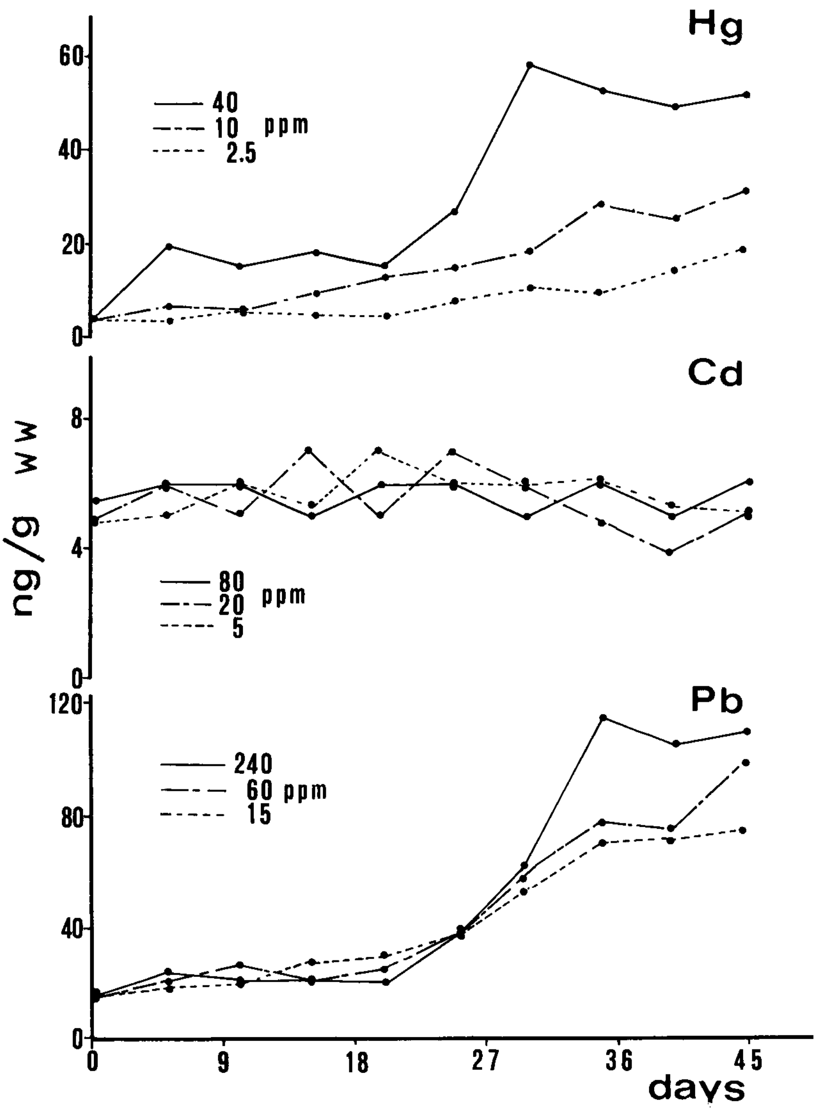

Figure 1. Metals concentrations in quail eggs during 45 days of treatment with Hg, Cd and Pb.

japonica) were kept on a basal diet until they produced a constant number of eggs (6 eggs per day per 10 quails); then metals in the following concentrations (expressed in mg/kg) were added to the diet of groups of four quails: mercury, 2.5, 10, 40; cadmium, 5, 20, 80; lead, 15, 60, 240. Another group was used as control. During the 45 days of treatment the eggs of each group were collected daily and kept at 5°C until analysis. At the end of the experiment the animals were sacrified and processed for metals determination. Samples were mineralized in decomposition vessels of

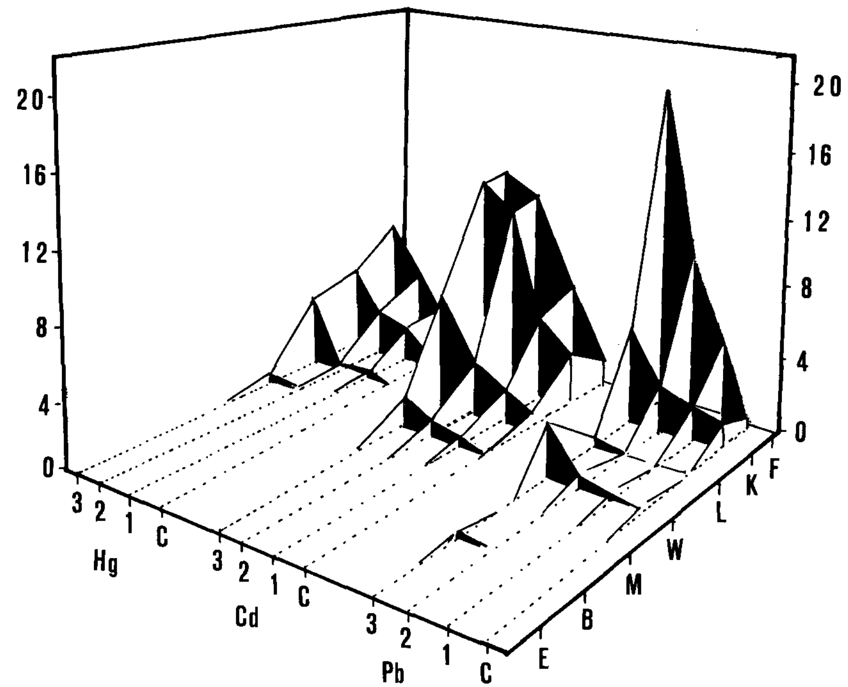

Figure 2. Concentrations of metals (ug/g w.w.) in different biological materials (F=faeces, K=kidney, L=liver, W=whole body, M=muscle, B=brain, E=egg) of quails after 45 days of treatment with Hg, Cd and Pb at different concentrations in the diet (C=control, 1,2,3= increasing levels in the diet as specified in the text).

teflon with HNO2 at 105 °C. Metals were detected by AAS using the cold vapour technique for mercury and the grafite furnace for cadmium and lead. All data is based on wet weight. In all examined materials detection limits were 2-3, 3-4, 30-40 ng/g for Hg, Cd and Pb, respectively; precision and accuracy were evaluated by calibration with certificate standards (NBS, IAEA). Statistical analysis was performed on an IBM P-30 personal computer using the SPSS program for variance and regression analysis and 3D and Assist2 for graphics.

RESULTS AND DISCUSSION

There was no decrease in egg production in the treated groups with respect to controls. The levels of metals in the eggs as a function of time of exposure are shown in Fig.1.

Mercury showed a slight increase in all the groups and the animals treated with 40ppm reached the highest

levels at the end of the experiment. Values were from two to ten times those of controls which was significant ($p < 0.05$) in all cases.
Cadmium content ranged from 2 to 7 ng/g independent of time and the dose.
Lead showed a linear increase during the period of the experiment. There were no differences between groups. At the end of treatment, levels were about 5 times those of controls and statistically significant ($p < 0.05$).
In Fig.4 the average concentrations of Hg, Cd and Pb in tissues, eggs and faeces of treated quails are compared. The greatest quantity of metals was found in the faeces. Relatively high levels were also found in the kidney, liver and whole body whereas muscle, brain and egg concentrations were comparatively much lower. For example the ratio between diet and biological sample levels of Hg, Cd and Pb at the highest dose was 5.3, 7.8 and 12.0 for faeces but 800, 4000 and 2400 for the eggs of the same animals. In other words, the concentrations of metals in the egg are hundreds or thousand of times lower than in the diet whereas those in the faeces are almost of the same order. In the eggs, the levels of metals were often very close to the common detection limits for AAS techniques and it was almost impossible to correlate the different doses given to the groups with the results of the analysis of the eggs. Eggs were therefore the least sensitive biological indicator of metal exposure, having a response similar to that of the brain and muscle. On the contrary the faeces were the most sensitive, giving a response in terms of metal concentrations which was several orders of magnitude higher than eggs and closely reflected the different inputs to which the animals were subjected.

From these findings it is clear that bird eggs are poor monitors of heavy metals intake in environmental studies. Faeces have been demonstrated to be a more suitable material which can be easily collected, especially to monitor colonial species of birds congregating in well defined areas. Due to their high metal content, there is practically no risk of contamination during sampling or laboratory procedures and no problem of instrumental sensistivity or matrix interference (Koiker, 1986). Abandoned eggs and faeces monitors could be used for the combined assessment of organochlorine and heavy metals contamination even in threatened species.

REFERENCES

Amodio-Cocchieri R, Fiore P (1987) Lead and cadmium concentrations in liverstock bred in Campania, Italy. Bull Environ Contam Toxicol 39:460-464

Clark T, Clark K, Paterson S, Mackay D, Norstrom RJ (1988) Wildlife monitoring, modeling and fugacity. Env Sci Tecn 22:120-127
Hutton M (1981) Accumulation of heavy metals and selenium in three seebird species from the United Kingdom. Environ Pollut 26:129-145
Kooiker G (1986) Recommendations for analytical methods of heavy metals in bird eggs and feathers with atomic absorption spectrophotometry (AAS). J Ornithol 1:9-23
Mineau P, Fox GA, Norstrom RJ, Weseloh DV, Hallett DJ, Ellenton JA (1984) Using the Herring Gull to monitor levels and effects of organochlorine contamination in the Canadian Great Lakes. In: Nriagu JO and Simons MS (eds) Toxic Contaminants in the Great Lakes. J Wiley & Sons, New York, pp 426-452
Ohlendorf HM, Harrison CS (1986) Mercury, selenium, cadmium and organochlorines in eggs of three Hawaiian seabird species. Environ Pollut, Ser B 3:169-191
Renzoni A, Focardi S, Fossi C, Leonzio C (1986) Comparison between concentrations of mercury and other contaminants in eggs and tissues of Cory's Shearwater Calonectris diomedea collected on Atlantic and Mediterranean islands. Environ Pollut, Ser A 40:17-35

Received September 19, 1988; accepted April 9, 1989.