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Lead Contamination in the Mallard (*Anas platyrhynchos*) in Italy

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The main cause of lead poisoning in waterfowl is due to ingestion of spent lead shot in areas of high hunting pressure (Bellrose 1959). Italian literature on this subject is very scarce and the few available studies concern episodic cases (Del Bono 1970; Maestrini 1970; Galasso 1976; Perco et al. 1983; Di Modugno et al. 1994). To contribute to the assessment of the impact of lead shot on waterfowl in Italy, systematic research has been carried out on shorebirds caught for ringing in Tuscany (Tirelli and Tinarelli, in press) and are continuing on dabbling and diving ducks by checking the presence of lead in blood samples and lead shot in the gizzard.

The target species of the research described in this paper is the mallard (*Anas platyrhynchos*). According to Sanderson and Bellrose (1986), it is highly susceptible to lead poisoning due to its high tendency to ingest lead shot as grit and to its food habits (mainly cereal grains and weed seeds). This kind of diet, rich in carbohydrates and poor in protein, calcium and phosphorus, enhances the absorption of lead into the blood. Ingested lead shot is completely eroded in the gizzard and absorbed in the blood stream within 3 weeks in 90 % of the affected birds. Thus, lead concentration in the blood and delta-aminolevulinic acid dehydratase (δ-ALA-d) activity are the best indicators of a recent lead exposure (as early as 8 hours after lead ingestion) and indicate the degree of lead poisoning over a short period.

In fact, blood lead concentration remains elevated for as much as 45 days after lead ingestion (Samuel et al. 1992) and δ-ALA-d activity remains depressed for several months after exposure to lead (Pain 1992).

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MATERIALS AND METHODS

During autumn 1990, 62 mallards were caught for ringing in the World Wildlife Found Refuge of the lagoon of Orbetello (Tuscany, Italy) which is an important area for migrant and wintering waterfowl. Hunting has been forbidden in the whole lagoon since 1994, but was forbidden formerly only in the W.W.F. Refuge.

A blood sample of 2 ml was taken from each individual, then each was sexed, aged, ringed and released. The presence of lead in blood was analyzed by Atomic Absorption Spectrophotometer with graphite furnace, following the procedures reported in Minoia et al. (1979). The detection limit was less than 0.4 μg/100 ml and the percent recoveries were between 96 and 97 %.

We also analyzed for δ-aminolevulinic acid dehydratase (δ-ALA-d) activity in 21 of the mallard samples and the measure was performed according to the method of Berlin and Schaller (1974). Lead content is expressed in μg/dl and enzymatic activity is expressed in U/ml (nanomoles δ-ALA/min/ml red blood cells). Differences between sex and age classes were tested using Chi-square. Correlation between lead levels and δ-ALA-d was tested using Spearman correlation coefficient.

RESULTS AND DISCUSSION

Lead was present in the blood of all mallards sampled (x = 46 μg/dl, s.d. = 25, min. 10 μg/dl, max. 120 μg/dl) (Table 1). Lead and d-ALA-d activity were negatively correlated ($r_s = -0.873$, $P < 0.0000$) (Fig. 1). Lead concentrations in males were higher than in females and the δ-ALA-d activity was higher in females than in males. This may have been due to differences in food habits and habitat preference (Samuel et al. 1992) and to the loss of lead from bones and blood during the breeding season (Sanderson and Bellrose 1986), probably during eggshell formation. No significant differences in lead concentrations were noted between young mallards and adults as reported for black ducks (*Anas rubripes*) by Samuel et al. (1992).

The pattern of δ-ALA-d activity inhibition in mallards from the lagoon of Orbetello (Fig. 1) was similar to that described for black ducks by Pain (1989) and for mallards by Scheuhammer (1989). The data reported here suggest that the inhibition of δ-ALA-d activity may be a good indicator of lead intoxication for lead levels in blood higher than 60 μg/dl. Despite the great amount of information available on the concentration of lead in tissues of ducks with clinical symptoms or found dead by lead poisoning, little information concerning correlations between blood lead levels and clinical symptoms in birds are reported in the literature. In addition, there is disagreement concerning those blood levels which are dangerous or not dangerous. Lumeij (1985) reported values of blood lead concentration in mallards with

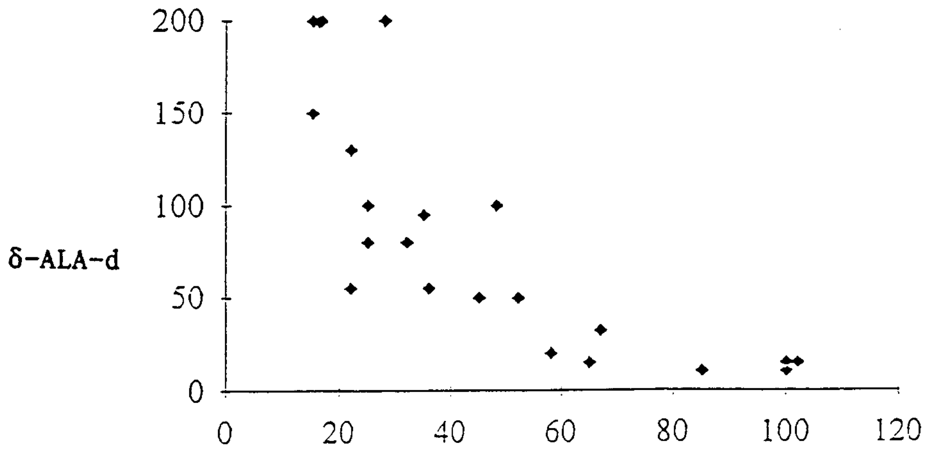

Figure 1. Correlation between blood lead concentration and the activity of delta-aminolevulinic acid dehidratase (δ-ALA-d) in mallards. Spearman correletion coefficient rs = - 0.873, $P < 0.0000$.

Table 1. Lead concentration and delta-aminolevulinic acid dehidratase (δ-ALA-d) activity in the blood of mallards.

Sex	Pb µg/dl				δ-ALA-d U/ml			
	N.	x	s.d.	range	N.	x	s.d.	range
males	51	49	26	15-120	18	64	54	10-200
females	11	33	14	10- 50	3	167	58	100-200
males and females	62	46	25	10-120	21	79	64	10-200

clinical signs of lead poisoning ranging between 52 µg/dl and 5,840 µg/dl. According to these values, 35.5 % of the mallards analyzed in this study were poisoned.
Pain (1989) suggested that birds with lead levels in blood higher than 40 µg/dl, and probably even with 25-30 µg/dl, have ingested lead shot. Daury et al. (1993) used 100 µg/dl of lead in blood as a conservative threshold level indicating exposure to non-background concentrations of lead in waterfowl. According to these authors, 54.8 % of the investigated mallards had blood lead concentrations higher than 40 µg/dl, the higher limit proposed by Pain (1989), and 6.5 % had blood lead concentrations higher than 100 µg/dl. Only 8 % of the mallards had blood lead concentrations ≤ 15 µg/dl, considered by Scheuhammer (1989) as an index of absence of dangerous lead contamination and as a consequence of exposure to industrial pollution.

All the mallards studied appeared to be in good health during ringing operations. However, birds may survive with high blood lead concentrations without apparent symptoms of poisoning because of the production of nuclear inclusion bodies (Lumeij 1985). There is also the possibility that red blood cells produce metallothionein-like proteins which can bind lead, sequestering it into a non bioavailable form, hence protecting an organism against lead toxicity (Church et al. 1993).

This study pointed out that, as in other countries, some mallards in Italy are undoubtedly affected by lead poisoning caused by the ingestion of lead shot. Their deaths in small numbers from day-to-day go unnoticed because sick and dead birds are rapidly removed by predators and scavengers. The birds that do not die of acute lead poisoning may suffer sub-lethal effects and, perhaps, may be more vulnerable to human and animal predation.

Lead poisoning in waterbirds may be eliminated. In fact, in other countries such as the USA, Canada and Denmark, where the significance of lead poisoning mortality has long been recognized, lead shot has been replaced by non-toxic shot.

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