Experimental manipulation of dietary arsenic levels in great tit nestlings: effects on antioxidant molecules and lipid peroxidation

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INTRODUCTION AND OBJECTIVE

Arsenic (As) is a metalloid of high concern because of its toxic effects, but it has been poorly studied in birds. In the wild, it is difficult to demonstrate a causal link between levels of specific pollutants and health impairments. In addition, long-term pollution may produce changes in food quantity and quality and secondary effects on birds. Therefore, As manipulation experiments in free-living bird populations are needed to explore its specific adverse effects. The main objective of this study is to explore the effects of environmentally relevant As levels on oxidative stress biomarkers of great tits (Parus major).

MATERIAL AND METHODS

The As supplementation experiment was conducted in 2015 in the surroundings of a Cu-Ni smelter in Harjavalta, SW Finland (Fig. 1a). Great tit nestlings were orally dosed with sodium arsenite (d3-d13, n=70 broods) in three experimental groups (Control, Low, and High: 0, 0.2, and 1 µg/g/d, Fig. 1b) and were compared with those living in the vicinity of a Cu-Ni smelter, an As source (Smelter group, 0 µg/g/d). We studied a set of antioxidant molecules (glutathione peroxidase, GPx; glutathione-S-transferase, GST; catalase, CAT; superoxide dismutase, SOD; glutathione, GSH) and lipid peroxidation as TBARS (thiobarbituric acid reactive substances) levels in red blood cells. Feces were collected to measure As concentrations by ICP-OES.

RESULTS AND DISCUSSION

Fecal As concentrations were significantly higher in the Smelter group, followed by the Low group, and finally the Control group with the lowest levels (F_{ddf,df} = 15.40, p<0.001; Fig. 2). Although nestlings from the High As group showed higher GST and SOD activity and GSH and TBARS levels than the Control group, no significant differences were found (Table 1). CAT activity was significantly lower in the High As group, while GPx was significantly higher in the Smelter group when compared to the Control group (Table 1, Fig. 3).

The lower CAT activity in the High As group may reflect the ability of this metalloid to deplete the activity of this antioxidant enzyme.

The higher GPx activity in the polluted environment could reflect higher level of oxidative stress in nestlings from this area, probably due to the exposure to a mixture of metals and the associated limitation of resources (lower food quality and quantity) demonstrated before, showing the importance of secondary pollution effects on birds.

ACKNOWLEDGEMENTS

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REFERENCES


Table 1: Generalized linear mixed models (GLMM) of the effect of treatment (Control, Low, High and Smelter) on oxidative stress biomarkers in great tit nestlings.

<table>
<thead>
<tr>
<th>Dependent variable</th>
<th>F df,df</th>
<th>p</th>
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<tbody>
<tr>
<td>GPx</td>
<td>3.526,38.73</td>
<td>0.026</td>
</tr>
<tr>
<td>GST</td>
<td>1.601,29.28</td>
<td>0.212</td>
</tr>
<tr>
<td>CAT</td>
<td>3.933,31.44</td>
<td>0.917</td>
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<tr>
<td>SOD</td>
<td>1.911,29.56</td>
<td>0.149</td>
</tr>
<tr>
<td>GSH (total)</td>
<td>1.456,55</td>
<td>0.239</td>
</tr>
<tr>
<td>TBARS</td>
<td>0.845,30.83</td>
<td>0.482</td>
</tr>
</tbody>
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Fig. 1. Cu-Ni smelter in Harjavalta, Finland (a), and As dosing of a great tit nestling (b).

Fig. 2. Mean (± 95% CI) As levels in feces. The data are predicted and back-transformed values from the GLM models. Numbers above the bars indicate the number of broods. *Significant differences between treatment group and control (Dunnett’s test).

Fig. 3. Mean (± 95% CI) GPx (pmol/min/mg) and CAT (µmol/min/mg) activities in red cells of great tit nestlings by treatment. The data are predicted values from the GLMM models shown in Table 1. *Significant differences between treatment group and control (Dunnett’s test). Numbers above the bars indicate the number of broods.