Pollution-related changes in carotenoid-based plumage coloration of great tit nestlings – roles of food quality and oxidative stress

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Introduction

Birds need to acquire carotenoids for antioxidants and feather pigmentation from their diet. Lutein is the main yellow pigment in the great tit plumage, herbivorous caterpillars being an important source of this pigment. In 1990’s we noticed that great tit nestlings are less yellow in the area polluted by metals (around a copper smelter). The roles of direct toxic effects and indirect effects via changed food chain are, however, not yet well understood. We tested four hypotheses to explain the variation in plumage color.

Hypotheses and methods

I - Variation in dietary carotenoid levels: we measured the number of carotenoid-rich caterpillars and tissue levels of carotenoids in birds in polluted and unpolluted environments.

II - Pollution-related change in transfer of carotenoids to feathers: we manipulated dietary carotenoid levels in polluted and unpolluted environments.

III - Condition dependent expression of carotenoid-based plumage color: we manipulated diet quantity and quality in polluted and unpolluted environments.

IV - Pollution-related oxidative stress and consequent carotenoid (antioxidant) depletion: we measured biomarkers of oxidative stress (e.g. GP, glutathione peroxidase) in polluted and unpolluted environments.

Results

I - Nestlings were less yellow close to the pollution source (Fig. 1). Caterpillar numbers correlated positively with the distance to the pollution source (Fig 2). Caterpillar numbers correlated positively with plumage yellowness of great tit nestlings.

II - Lutein supplementation increased tissue levels (Fig. 3a) and increased plumage color intensity (Fig 3b), but the response was similar in both environments.

III - Nestlings grew slower in the polluted area, but there was no clear relationship between body mass and color: color is not condition dependent in nestlings (Fig. 4).

IV - No correlation between the measures of oxidative stress and fecal metal levels (Fig. 5). No correlation between the measures of oxidative stress and plumage color.

Summary

I - Deficiency of carotenoids in diet: Correlational support² and experimental support³

II - Pollution-related change in transfer of carotenoids to feathers: Not supported³

III - Condition dependent expression of carotenoid-based plumage color: Not supported⁴

IV - Pollution-related oxidative stress and consequent carotenoid (antioxidant) depletion: Not supported⁵

Conclusions

Great tit nestlings are less yellow in the polluted environment because their diet contains less carotenoids; not because of oxidative stress or worse condition. Our study emphasizes the importance of indirect effects of environmental pollution on birds.

References
