# Cadmium Toxicity in Birds: Updating the Toxicity Reference Value used in Predictive Ecological Risk Assessments in California

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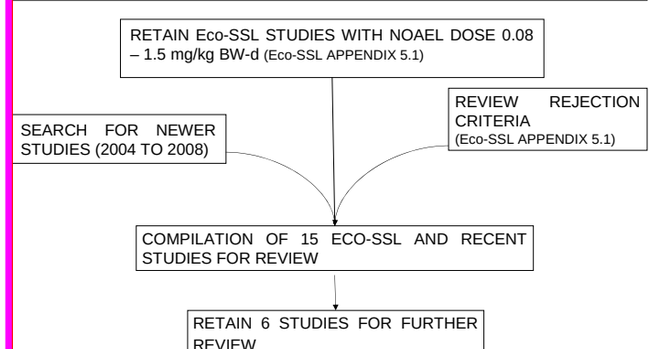
## INTRODUCTION

In a cooperative effort begun in 1995, the U.S. Department of the Navy and the U.S. Environmental Protection Agency (USEPA) Region 9 Biological Technical Assistance Group (BTAG) developed an avian cadmium low toxicity reference value (TRV) of 0.08 mg/kg body weight per day (BW/d) (Engineering Field Activity West, 1997). This no observable adverse effect level (NOAEL) was derived by applying an uncertainty factor of 10 to an unbounded lowest observable adverse effect level (LOAEL) of 0.8 mg/kg BW/d (Cain et al., 1983) for kidney degeneration in mallards. The Cain et al. (1983) study was selected over other studies because the mallard was considered to be a sensitive species, and the kidney was a known target organ for cadmium toxicity. The TRV-high as a mid-range adverse effect level was established at 10.43 mg/kg BW/d based on decreased body weight and testes weight in Japanese quail exposed to cadmium chloride (Richardson and Spivey Fox 1974).

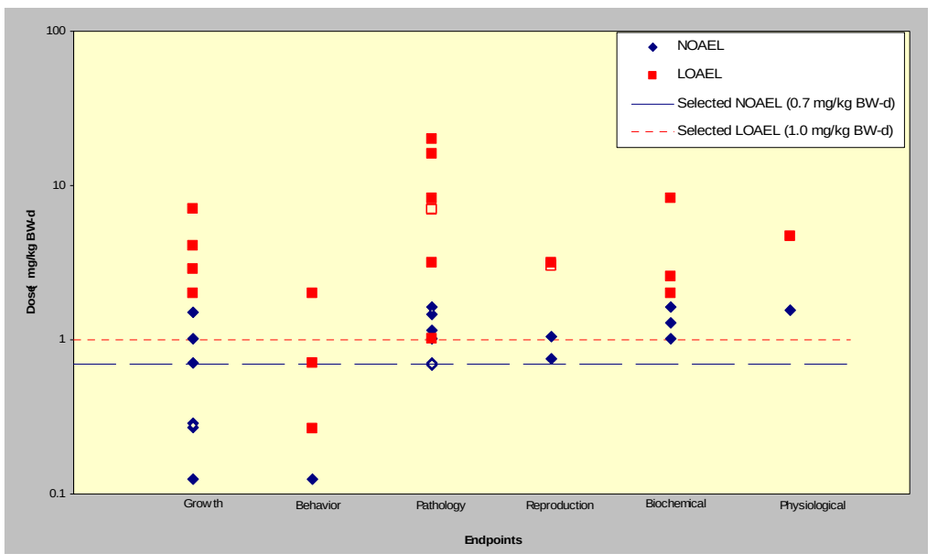
The current understanding of cadmium impacts to avian species has been improved by recent studies and the extensive literature review completed during the development of the USEPA Ecological Soil Screening Levels (Eco-SSLs). However, the cadmium Eco-SSL TRV for birds was derived as the geometric mean of NOAEL values for reproduction and growth (1.47 mg/kg BW/d; USEPA, 2005). BTAG members other than USEPA do not concur with some of the methodology used to develop this Eco-SSL, including: limiting the selection of a TRV-Low to reproduction, growth and mortality endpoints; calculating a geometric mean TRV based on different endpoints, studies, and species; and excluding unbounded LOAELs. Therefore, we sought to update the cadmium TRV for birds used by regulatory agencies and resource trustees in California for predictive ecological risk assessments.

## METHODS

We surveyed the available secondary and primary literature sources to identify the lowest, ecologically relevant NOAELs for oral exposure of birds to cadmium. Review focused on evaluating TRVs between the original BTAG TRV (0.08 mg/kg BW/d) and the Eco-SSL TRV (1.47 mg/kg BW/d), considering the application of an updated ingestion rate models (Nagy et al., 2001) and uncertainty factors.




| Reference | Test Species | Exposure Duration | Age | Effect Group | Effect Measure | NOAEL Dose (mg/kg/day) | LOAEL Dose (mg/kg/day) | Conclusion |
|---|---|---|---|---|---|---|---|---|
| Jacobs et al, 1978 | Japanese Quail | 7 d | 7 d | Growth | Body Weight | 0.1 | | |
| Jacobs et al, 1978 | Japanese Quail | 7 d | 7 d | Behavior | Food Consumption | 0.1 | | |
| Leach et al, 1979 | Chicken | 12 w | 8 mo | Reproduction | Egg Production | 0.2 | 0.8 | Retain |
| Teshfam et al., 2006 | Chicken | 48 d | 1 d | Growth | Body Weight | 0.3 | 2.9 | |
| Stoewsand et al 1986 | Japanese Quail | 63 d | 1 d | Growth | Body Weight | 0.3 | | |
| Mayack et al, 1981 | Wood duck | 12 w | 1 w | Pathology | Kidney Histology | 0.7 | 7.0 | Retain |
| Lefevre et al, 1982 | Chicken | 5 w | 1 d | Pathology | Lung Weight | 0.7 | 7.1 | |
| Lefevre et al, 1982 | Chicken | 5 w | 1 d | Growth | Body Weight | 0.7 | 7.1 | |
| Leach et al, 1979 | Chicken | 12 mo | 6 mo | Reproduction | Egg Production | 0.8 | 3.0 | Retain |
| Leach et al, 1979 | Chicken | 6 w | 1 d | Growth | Body Weight | 1.0 | 4.0 | Retain |
| Cain et al, 1983 | Mallard Duck | 12 w | 1 d | Biochemical | Hemoglobin | 1.0 | | Retain |
| Cain et al, 1983 | Mallard Duck | 12 w | 1 d | Growth | Body Weight | 1.0 | | Retain |
| Cain et al, 1983 | Mallard Duck | 12 w | 1 d | Pathology | Liver Weight | 1.0 | | Retain |
| Bokori et al, 1996 | Chicken | 39 w | 14 d | Pathology | Relative Liver Weight | 1.1 | 3.2 | Retain |
| Bokori et al, 1996 | Chicken | 39 w | 14 d | Reproduction | Testes Weight | 1.1 | 3.2 | Retain |
| White and Finley, 1978 | Mallard Duck | 90 d | 1 yr | Pathology | Kidney Weight | 1.2 | 16.0 | Retain |
| Blalock and Hill, 1988 | Chicken | 2 w | 1 d | Biochemical | Hemoglobin | 1.3 | 2.6 | |
| Hill, 1974 | Chicken | 2 w | 1 d | Growth | Body Weight | 1.5 | | |
| White et al 1978 | Mallard | 60 d | 1 yr | Pathology | Relative Kidney Weight | 1.5 | 20.0 | Retain |
| Bokori et al, 1996 | Chicken | 5 w | 14 d | Physiological | Food Conversion Efficiency | 1.6 | 4.7 | Retain |
| Pilastro et al, 1993 | Starling | 22 w | NR | Biochemical | Liver NADPH cytochrome C reductase activity | 1.6 | 8.2 | |
| Pilastro et al, 1993 | Starling | 22 w | NR | Pathology | Relative Liver Weight | 1.6 | 8.2 | |
| Silver and Nudds, 1995 | American black duck | 106 d | NR | Behavior | general activity levels | | 0.3 | |
| Lefevre et al, 1982 | Chicken | 5 w | 1 d | Behavior | Food Consumption | | 0.7 | |
| Cain et al, 1983 | Mallard Duck | 12 w | 1 d | Pathology | Kidney Nephrosis | | 1.0 | Retain |
| Fadil and Magid, 1996 | Chicken | 30 d | 1 d | Behavior | Food Consumption | | 2.0 | |
| Fadil and Magid, 1996 | Chicken | 30 d | 1 d | Growth | Body Weight | | 2.0 | |
| Fadil and Magid, 1996 | Chicken | 30 d | 1 d | Biochemical | Red Blood Cell | | 2.0 | |




## RESULTS AND CONCLUSIONS

The BTAG has updated the current avian TRVs for cadmium. After consideration of the endpoints, dosing information, evaluation of the experimental results, updated ingestion rate models (Nagy et al., 2001), and limitations of the experiments, the BTAG recommends an avian cadmium NOAEL (TRV-Low) at 0.7 mg/kg BW/day, based primarily on the kidney toxicity data contained in Mayack et al. (1981). The determination is supported by at least five other studies suggesting that a 0.7 mg/kg BW/day cadmium dose would be protective of reproductive, growth, and renal effects seen at doses within one order of magnitude. In addition, the most sensitive, ecologically relevant LOAEL was identified as 1.0 mg/kg/d based on kidney nephrosis in mallards (Cain et al., 1983). This LOAEL is supported by other studies identifying potential reproductive effects near this dose, such as White et al. (1978) and Leach et al. (1979).

| TRV | Dose (mg/kg BW/d) | Endpoint | Study |
|---|---|---|---|
| Original BTAG NOAEL / TRV - low | 0.08 | Kidney histology in mallards with uncertainty factor of 10 | Cain et al., 1983 |
| Updated BTAG NOAEL / TRV - low | 0.7 | Kidney histology in wood ducks | Mayack et al., 1981 |
| New BTAG LOAEL | 1.0 | Kidney histology in mallards | Cain et al., 1983 |
| Eco-SSL geomean NOAEL | 1.47 | Geometric mean of growth and reproduction | EPA, 2005 |
| BTAG mid-range effect level / TRV - high | 10.43 | decreased body weight and testes weight in Japanese quail | Richardson and Spivey Fox 1974 |

The newly selected Cd TRVs are based on exposure to Cd chloride, a soluble and bioavailable form of Cd. If Cd has hazard quotients above one during the screening level ecological risk assessment using the updated avian TRV-Low, the form(s) of Cd present on-site and their site-specific bioavailability or bioaccessibility relative to Cd chloride should be determined.

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