

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

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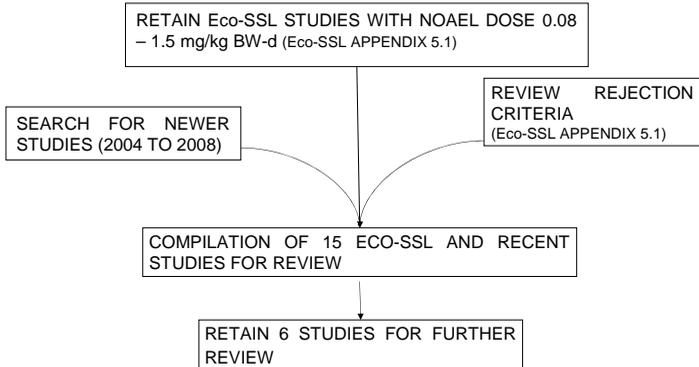
INTRODUCTION

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).

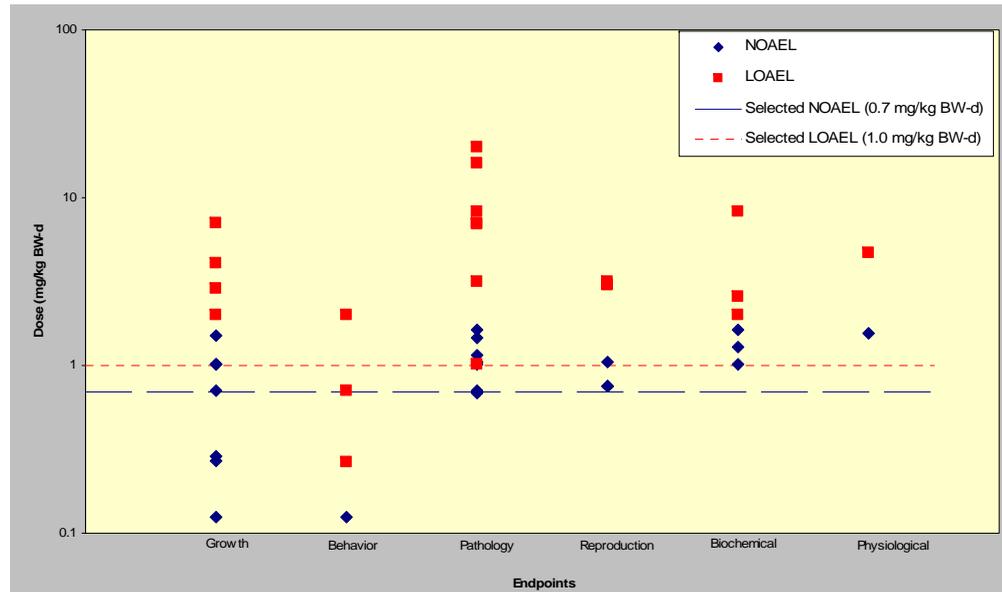
The current understanding of cadmium impacts to avian species has been improved by recent studies and the extensive literature review completed during the development of the USEPA Ecological Soil Screening Levels (Eco-SSLs). However, the cadmium Eco-SSL TRV for birds was derived as the geometric mean 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
Black 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 geometric 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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