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Appendix 6-1  Mammalian Toxicity Data Extracted and Reviewed for Wildlife Toxicity Reference Value (TRV) - Zinc
1.0 INTRODUCTION

Ecological Soil Screening Levels (Eco-SSLs) are concentrations of contaminants in soil that are protective of ecological receptors that commonly come into contact with and/or consume biota that live in or on soil. Eco-SSLs are derived separately for four groups of ecological receptors: plants, soil invertebrates, birds, and mammals. As such, these values are presumed to provide adequate protection of terrestrial ecosystems. Eco-SSLs are derived to be protective of the conservative end of the exposure and effects species distribution, and are intended to be applied at the screening stage of an ecological risk assessment. These screening levels should be used to identify the contaminants of potential concern (COPCs) that require further evaluation in the site-specific baseline ecological risk assessment that is completed according to specific guidance (U.S. EPA, 1997, 1998, and 1999). The Eco-SSLs are not designed to be used as cleanup levels and the United States (U.S.) Environmental Protection Agency (EPA) emphasizes that it would be inappropriate to adopt or modify the intended use of these Eco-SSLs as national cleanup standards.

The detailed procedures used to derive Eco-SSL values are described in separate documentation (U.S. EPA, 2003, 2005). The derivation procedures represent the collaborative effort of a multi-stakeholder group consisting of federal, state, consulting, industry, and academic participants led by what is now the U.S. EPA Office of Solid Waste and Emergency Response (OSWER).

This document provides the Eco-SSL values for zinc and the documentation for their derivation. This document provides guidance and is designed to communicate national policy on identifying zinc concentrations in soil that may present an unacceptable ecological risk to terrestrial receptors. The document does not, however, substitute for EPA’s statutes or regulations, nor is it a regulation itself. Thus, it does not impose legally-binding requirements on EPA, states, or the regulated community, and may not apply to a particular situation based upon the circumstances of the site. EPA may change this guidance in the future, as appropriate. EPA and state personnel may use and accept other technically sound approaches, either on their own initiative, or at the suggestion of potentially responsible parties, or other interested parties. Therefore, interested parties are free to raise questions and objections about the substance of this document and the appropriateness of the application of this document to a particular situation. EPA welcomes public comments on this document at any time and may consider such comments in future revisions of this document.
2.0 SUMMARY OF ECO-SSLs FOR ZINC

Zinc is found in almost all minerals and is ranked as the twenty-third most abundant element in the earth's crust. The principal ores of zinc are sphalerite, smithsonite, calamine, and franklinite (O'Neill, 2001; Lide, 2005). Elemental zinc is not found in the environment but instead occurs in compounds in the 2+ oxidation state, often as zinc sulfide or zinc oxide (HSDB).

Zinc is released to the environment from both natural and anthropogenic sources, the latter being the most important. Zinc has many commercial uses as coatings to prevent corrosion for electrical apparatus such as dry cell batteries, and mixed with other metals to make alloys like brass, and bronze (O'Neill, 2001). Zinc compounds such as zinc chloride, zinc oxide and zinc sulfate are used in herbicides, fungicides and bacteriostats. Zinc may also be released to the environment from its use in rubbers, paints, and cosmetics (ATSDR, 2005; Goodwin, 1998; ANL, 2005) and as the result of metal smelting, mining, electroplating, coal and oil combustion, and waste incineration (ATSDR, 2005; Ursinyova, 1999). Urban runoff from building siding and roofs, automobile brakes, tires, and oil leakage is another important source of zinc in the environment (Davis, 2001)(HSDB).

Total zinc content in soils is dependent on the composition of the parent rock material (Kiekens, 1990; HSDB). The total amount of zinc in soils is distributed as one of three forms: 1) free ions (Zn2+) and organo-zinc complexes in soil solution; 2) adsorbed and exchangeable zinc in the colloidal fraction of the soil and 3) secondary minerals and insoluble complexes in the solid phase of the soil. The distribution of zinc among the forms is dependant on the concentration of Zn2+ and other ions in the solution, the kind and amount of adsorption sites associated with the solid phase of the soil, the concentration of all ligands capable of forming organo-zinc complexes, and pH and redox potential of soil (Alloway, 1990). Background concentrations reported for many metals in U.S. soils are described in Attachment 1-4 of the Eco SSL guidance (U.S. EPA, 2003). Typical background concentrations of zinc in U.S. soils are plotted in Figure 2.1 for both eastern and western U.S. soils.

Zinc is expected to demonstrate low mobility in most soils, and is strongly adsorbed to soils at pH 5 or greater (Evans, 1989; Blume, 1991; Christensen, 1996). Only those fractions of zinc in soil which are soluble or may be solubilized are bioavailable. Compared to total zinc content of soils, concentrations of zinc in soil solution are low. The solubility of zinc increases at decreasing pH (Alloway, 1990). The bioavailability of zinc in soils is also influenced by total zinc content, pH,
organic matter, microbial activity, moisture, and interactions with other macro and micronutrients (Kiekens, 1990; HSDB).

Zinc is an essential trace element for higher plants and animals. In higher plants zinc is absorbed as the divalent cation (Zn $^{2+}$) which is a metal component of enzymes or a functional, structural or regulatory cofactor of a large number of enzymes. Zinc is involved in carbohydrate and protein metabolism and is required for the synthesis of indoleacetic acid. In plants, zinc deficiency is commonly indicated by stunted growth, interveinal chlorosis, and leaf symptomatology such as small leaves, malformations, and dieback while zinc excess commonly produces iron chlorosis (Chapman, 1966, Kiekens, 1990).

In animals, zinc is an essential nutrient for regulating a number of metalloenzymes (ATSDR, 2005). Absorption of zinc occurs from all segments of the intestine, although the largest proportion of zinc absorption occurs from the duodenum (ATSDR, 2005). Following absorption by the intestine, zinc is rapidly distributed to the liver, kidneys, prostate, muscles, bones, and pancreas. Zinc salts adversely affect tissues, interfere with the metabolism of other ions such as copper, calcium, and iron, and inhibit erythrocyte production and function (ATSDR, 2005; WHO, 2001; ECB, 2004; HSDB).

Zinc deficiency has been associated with dermatitis, anorexia, growth retardation, poor wound healing, hypogonadism with impaired reproductive capacity, and impaired immune function (ATSDR, 2005). Nutritional requirements of zinc for common mammalian and avian test organisms are compiled in Attachment 4-3 of the Eco-SSL guidance (U.S. EPA, 2003, 2005). Zinc excess in avian species is associated with decreased body weight, gizzard and pancreatic lesions, and biochemical changes (WHO, 2001). Mammalian studies have shown vomiting, depressed growth rate, purgation, and ataxia (Clarke, 1981; Friberg, 1986; HSDB).

The Eco-SSL values derived to date for Zinc are summarized in Table 2.1.

<table>
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<th>Plants</th>
<th>Soil Invertebrates</th>
<th>Wildlife</th>
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<td>Mammalian</td>
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Eco-SSL values were derived for all receptor groups. The Eco-SSL values for zinc range from 46 mg/kg dry weight (dw) for avian wildlife to 160 mg/kg dw for terrestrial plants. The Eco-SSL for avian wildlife is less than the 25$^{th}$ percentile of reported background soil concentrations of zinc in western U.S. soils and less than the 75$^{th}$ percentile for eastern U.S. soils (Figure 2.1). The Eco-SSL for mammalian wildlife is less than the 96$^{th}$ percentile for both eastern and western U.S. soils (Figure 2.1). The Eco-SSLs for plants and soil invertebrates are higher than the 95$^{th}$ percentile for both eastern and western U.S. soils. The avian and mammalian Eco-SSL values are based on exposures of receptors consuming zinc in soil invertebrates.
3.0 ECO-SSL FOR TERRESTRIAL PLANTS

Of the papers identified from the literature search process, 680 papers were selected for acquisition for further review. Of those papers acquired, 78 met all 11 Study Acceptance Criteria (U.S. EPA, 2003; Attachment 3-1). Each of these papers were reviewed and the studies were scored according to the Eco-SSL guidance (U.S. EPA, 2003; Attachment 3-2). Thirty-nine study results received an Evaluation Score greater than ten (U.S. EPA, 2003; Attachment 3-1). These studies are listed in Table 3.1.

The studies in Table 3.1 are sorted by bioavailability score. There are five studies with a bioavailability score of 2 that are eligible for Eco-SSL derivation. These results were used to derive the plant Eco-SSL for zinc (U.S. EPA, 2003; Attachment 3-2). The Eco-SSL is the geometric mean of the maximum acceptable toxicant concentration (MATC) values for three species under different test conditions (pH and % organic matter (OM)) and is equal to 160 mg/kg dw.

4.0 ECO-SSL FOR SOIL INVERTEBRATES

Of the papers identified from the literature search process, 162 papers were selected for acquisition for further review. Of those papers acquired, 26 met all 11 Study Acceptance Criteria (U.S. EPA 2003; Attachment 3-1). Each of these papers were reviewed and the studies were scored according to the Eco-SSL guidance (U.S. EPA, 2003; Attachment 3-2). Forty studies received an Evaluation Score greater than ten. These studies are listed in Table 4.1.

The studies in Table 4.1 are sorted by bioavailability score. There are six studies with a bioavailability score of 2 that are eligible for Eco-SSL derivation. These results were used to derive the soil invertebrate Eco-SSL for zinc (U.S. EPA, 2003; Attachment 3-2). The Eco-SSL is the geometric mean of the EC10 and MATC values for at least three test species under different test conditions (pH and OM%) and is equal to 120 mg/kg dw.
### Table 3.1 Plant Toxicity Data - Zinc

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**Geometric Mean: 160**

Data Not Used to Derive Plant Eco-SSL:

- De Haan et al., 1985
- Roszyk et al., 1988
- Roszyk et al., 1988
- Singh and Jeng, 1993
- White et al., 1979
- Rehab and Wallace, 1978
- Roszyk et al., 1988
- Roszyk et al., 1988
- Roszyk et al., 1988
- Monette, 1978
- White et al., 1979
- Singh et al., 1991

Eco-SSL for Zinc | June 2007
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<th>Reference</th>
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<th>Bio-availability Score</th>
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EC_{10} = Effect concentration for 10% of test population
EC_{25} = Effect concentration for 25% of test population
EC_{50} = Effect concentration for 50% of test population
ERE = Ecologically relevant endpoint
GRO = Growth
LOAEC = Lowest observed adverse effect concentration
MATC = Maximum acceptable toxicant concentration. Geometric mean of NOAEC and LOAEC.
N = No
NOAEC = No observed adverse effect concentration
ns = Not specified
OM = Organic matter content
PHY = Physiology
REP = Reproduction
Y = yes
cnb = Could Not Be Determined
### Table 4.1  Invertebrate Toxicity Data - Zinc

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**Data not Used to Derive Soil Invertebrate Eco-SSL**

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- Spurgeon and Hopkin, 1996: 4067 b Earthworm Eisenia fetida
- Peredney and Williams, 2000b: 56449 y Nematode Caenorhabditis elegans
- Peredney and Williams, 2000b: 56449 aa Nematode Caenorhabditis elegans
- Donkin and Dusenbery, 1994: 7877 b Nematode Caenorhabditis elegans
- Van Gestel and Hensbergen, 1997: 10987 Springtail Folsomia candida
- Sandifer and Hopkin, 1996: 4056 a Springtail Folsomia candida
- Sandifer and Hopkin, 1996: 4056 b Springtail Folsomia candida
- Sandifer and Hopkin, 1996: 4056 c Springtail Folsomia candida
- Spurgeon et al., 1997: 4442 a Earthworm Eisenia fetida
- Smit and Van Gestel, 1998: 6159 a Springtail Folsomia candida
- Smit and Van Gestel, 1998: 6159 c Springtail Folsomia candida
- Van Gestel et al., 1993: 6828 Earthworm Eisenia andrei
- Sandifer and Hopkin, 1997: 758 Springtail Folsomia candida
- Spurgeon and Hopkin, 1996a: 7870 Earthworm Eisenia fetida
- Posthuma et al., 1997: 2380 a Earthworm Enchytraeus crypticus
- Posthuma et al., 1997: 2380 b Earthworm Enchytraeus crypticus
- Spurgeon and Hopkin, 1996c: 4067 c Earthworm Eisenia fetida
- Spurgeon and Hopkin, 1996c: 4067 d Earthworm Eisenia fetida
- Spurgeon and Hopkin, 1996c: 4067 e Earthworm Eisenia fetida
- Spurgeon et al., 1994: 4364 Earthworm Eisenia fetida
- Spurgeon et al., 1997: 4442 c Earthworm Eisenia fetida
- Smit and Van Gestel, 1996: 7869 a Springtail Folsomia candida

**Geometric Mean**: 120

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Eco-SSL for Zinc | June 2007
### Table 4.1  Invertebrate Toxicity Data - Zinc

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<th>Bio-availability Score</th>
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EC_{10} = Effect concentration for 10% of test population  
EC_{50} = Effect concentration for 50% of test population  
ERE = Ecologically relevant endpoint  
GRO = Growth  
ILL = Incipient lethal level  
LC_{50} = Concentration lethal to 50% of test population  
LOAEC = Lowest observed adverse effect concentration  
MATC = Maximum acceptable toxicant concentration  
MOR = Mortality  
N = No  
NOAEC = No observed adverse effect concentration  
OM = Organic matter content  
POP = Population  
REP = Reproduction  
Y = Yes  
5.0 ECO-SSL FOR AVIAN WILDLIFE

The derivation of the Eco-SSL for avian wildlife was completed as two parts. First, the toxicity reference value (TRV) was derived according to the Eco-SSL guidance (U.S. EPA, 2003; Attachment 4-5). Second, the Eco-SSL (soil concentration) was back-calculated for each of three surrogate species representing different trophic levels based on the wildlife exposure model and the TRV (U.S. EPA, 2003).

5.1 Avian TRV

The literature search completed according to the Eco-SSL guidance (U.S. EPA, 2003; Attachment 4-1) identified 10,410 papers with possible toxicity data for either avian or mammalian species. Of these studies, 10,259 were rejected for use as described in Section 7.5. Of the remaining studies, 53 contained data for avian test species. These papers were reviewed and the data were extracted and scored according to the Eco-SSL guidance (U.S. EPA, 2003; Attachment 4-3 and 4-4). The results of the data extraction and review are provided as Table 5.1. The complete results are included as Appendix 5-1.

Within the reviewed papers, there are 168 results for biochemical (BIO), behavior (BEH), physiology (PHY), pathology (PTH), reproduction (REP), growth (GRO), and survival (MOR) effects that meet the Data Evaluation Score of >65 for use to derive the TRV (U.S. EPA, 2003; Attachment 4-4). These data are plotted in Figure 5.1 and correspond directly with the data presented in Table 5.1. The no-observed adverse effect level (NOAEL) results for growth and reproduction are used to calculate a geometric mean. This result is examined in relationship to the lowest bounded lowest-observed adverse effect level (LOAEL) for reproduction, growth, and survival to derive the TRV according to procedures in the Eco-SSL guidance (U.S. EPA, 2003; Attachment 4-5).

A geometric mean of the NOAEL values for reproduction and growth was calculated at 66.1 mg zinc/kg bw/day. This value is lower than the lowest bounded LOAEL for reproduction, growth, or survival. Therefore, the TRV is equal to the geometric mean of NOAEL values within the reproduction and growth effect groups and is equal to 66.1 mg zinc/kg bw/day.
Table 5.1
Avian Toxicity Data Extracted for Wildlife Toxicity Reference Value (TRV)

Zinc

Page 1 of 3

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Eco-SSL for Zinc
June 2007
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Zinc

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<td>71 Jackson et al, 1986</td>
<td>Chicken (Gallus domesticus)</td>
<td>5</td>
<td>FD</td>
<td>3 w</td>
<td>JV</td>
<td>M</td>
<td>H</td>
<td>NR</td>
<td>GST</td>
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<td>73</td>
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<tr>
<td></td>
<td>72 Van Vleet et al, 1981</td>
<td>Duck (Anas platyrhynchos)</td>
<td>U</td>
<td>FD</td>
<td>15 d</td>
<td>JV</td>
<td>M</td>
<td>H</td>
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<td></td>
<td>73 Van Vleet et al, 1981</td>
<td>Duck (Anas platyrhynchos)</td>
<td>U</td>
<td>FD</td>
<td>15 d</td>
<td>JV</td>
<td>M</td>
<td>H</td>
<td>NICRO</td>
<td>PS</td>
<td>803.0</td>
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<tr>
<td></td>
<td>74 Berry and Brake, 1990</td>
<td>Chicken (Gallus domesticus)</td>
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<td>JV</td>
<td>B</td>
<td>ORW</td>
<td>SMIX</td>
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<td>Growth (GRO)</td>
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<td>Chicken (Gallus domesticus)</td>
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<td>12 w</td>
<td>JV</td>
<td>M</td>
<td>REP</td>
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<td>WO</td>
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<td>JV</td>
<td>M</td>
<td>REP</td>
<td>PROG</td>
<td>WO</td>
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<tr>
<td></td>
<td>77 Jensen and Maurice, 1980</td>
<td>Chicken (Gallus domesticus)</td>
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<td>JV</td>
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<td>78 Jackson et al, 1986</td>
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<td>REP</td>
<td>PROG</td>
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<td>79 Gibson et al, 1986</td>
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<td>81 Gibson et al, 1986</td>
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<td>30 w</td>
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<td>82 Stevenson et al, 1987</td>
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<td>FD</td>
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<td>Chicken (Gallus domesticus)</td>
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<td>JV</td>
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<td>PROG</td>
<td>WO</td>
<td>88.0</td>
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<tr>
<td></td>
<td>86 Jensen and Maurice, 1980</td>
<td>Chicken (Gallus domesticus)</td>
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<td>JV</td>
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<tr>
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<td>87 Stepinska et al, 1987</td>
<td>Chicken (Gallus domesticus)</td>
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<td>FD</td>
<td>5 d</td>
<td>JV</td>
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<td>REP</td>
<td>PROG</td>
<td>WO</td>
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<tr>
<td></td>
<td>88 Jackson et al, 1986</td>
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<td>1 w</td>
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<td>M</td>
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<tr>
<td></td>
<td>89 Berry and Brake, 1985</td>
<td>Chicken (Gallus domesticus)</td>
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<td>FD</td>
<td>4 d</td>
<td>JV</td>
<td>M</td>
<td>REP</td>
<td>PROG</td>
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<td></td>
<td>90 Berry and Brake, 1990</td>
<td>Chicken (Gallus domesticus)</td>
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<td>JV</td>
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<td>REP</td>
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<tr>
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<td>86 Jensen and Maurice, 1980</td>
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<td>JV</td>
<td>M</td>
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<td>WO</td>
<td>88.0</td>
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<td></td>
<td>87 Stepinska et al, 1987</td>
<td>Chicken (Gallus domesticus)</td>
<td>U</td>
<td>FD</td>
<td>5 d</td>
<td>JV</td>
<td>M</td>
<td>REP</td>
<td>PROG</td>
<td>WO</td>
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<tr>
<td></td>
<td>88 Jackson et al, 1986</td>
<td>Chicken (Gallus domesticus)</td>
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<td>FD</td>
<td>1 w</td>
<td>JV</td>
<td>M</td>
<td>REP</td>
<td>PROG</td>
<td>WO</td>
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<tr>
<td></td>
<td>89 Berry and Brake, 1985</td>
<td>Chicken (Gallus domesticus)</td>
<td>U</td>
<td>FD</td>
<td>4 d</td>
<td>JV</td>
<td>M</td>
<td>REP</td>
<td>PROG</td>
<td>WO</td>
<td>803.0</td>
<td>73</td>
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<tr>
<td></td>
<td>90 Berry and Brake, 1990</td>
<td>Chicken (Gallus domesticus)</td>
<td>U</td>
<td>FD</td>
<td>49 d</td>
<td>JV</td>
<td>M</td>
<td>REP</td>
<td>PROG</td>
<td>WO</td>
<td>988.0</td>
<td>73</td>
</tr>
</tbody>
</table>

**Eco-SSL** for Zinc

June 2007
Table 5.1
Avian Toxicity Data Extracted for Wildlife Toxicity Reference Value (TRV)
Zinc

| Effect Type | Effect Measure | Sex | Reproductive Organ Histology | Sex Units | Age | Age Units | Life Stage | Route of Exposure | Method of Analysis | Route of Exposure | Method of Analysis | Route of Exposure | Method of Analysis | Route of Exposure | Method of Analysis | Route of Exposure | Method of Analysis | Route of Exposure | Method of Analysis | Route of Exposure | Method of Analysis | Route of Exposure | Method of Analysis | Route of Exposure | Method of Analysis |Route of Exposure | Method of Analysis | Route of Exposure | Method of Analysis | Route of Exposure | Method of Analysis |Route of Exposure | Method of Analysis | Route of Exposure | Method of Analysis |Route of Exposure | Method of Analysis | Route of Exposure | Method of Analysis |Route of Exposure | Method of Analysis | Route of Exposure | Method of Analysis |Route of Exposure | Method of Analysis | Route of Exposure | Method of Analysis |Route of Exposure | Method of Analysis | Route of Exposure | Method of Analysis |Route of Exposure | Method of Analysis | Route of Exposure | Method of Analysis |Route of Exposure | Method of Analysis | Route of Exposure | Method of Analysis |Route of Exposure | Method of Analysis | Route of Exposure | Method of Analysis |Route of Exposure | Method of Analysis | Route of Exposure | Method of Analysis |Route of Exposure | Method of Analysis | Route of Exposure | Method of Analysis |Route of Exposure | Method of Analysis | Route of Exposure | Method of Analysis |Route of Exposure | Method of Analysis | Route of Exposure | Method of Analysis |Route of Exposure | Method of Analysis | Route of Exposure | Method of Analysis |Route of Exposure | Method of Analysis | Route of Exposure | Method of Analysis |Route of Exposure | Method of Analysis | Route of Exposure | Method of Analysis |Route of Exposure | Method of Analysis | Route of Exposure | Method of Analysis |Route of Exposure | Method of Analysis | Route of Exposure | Method of Analysis |Route of Exposure | Method of Analysis | Route of Exposure | Method of Analysis |Route of Exposure | Method of Analysis | Route of Exposure | Method of Analysis |Route of Exposure | Method of Analysis | Route of Exposure | Method of Analysis |Route of Exposure | Method of Analysis | Route of Exposure | Method of Analysis |Route of Exposure | Method of Analysis | Route of Exposure | Method of Analysis |Route of Exposure | Method of Analysis | Route of Exposure | Method of Analysis |Route of Exposure | Method of Analysis | Route of Exposure | Method of Analysis |Route of Exposure | Method of Analysis | Route of Exposure | Method of Analysis |Route of Exposure | Method of Analysis | Route of Exposure | Method of Analysis |Route of Exposure | Method of Analysis | Route of Exposure | Method of Analysis |Route of Exposure | Method of Analysis | Route of Exposure | Method of Analysis |Route of Exposure | Method of Analysis | Route of Exposure | Method of Analysis |Route of Exposure | Method of Analysis | Route of Exposure | Method of Analysis |Route of Exposure | Method of Analysis | Route of Exposure | Method of Analysis |Route of Exposure | Method of Analysis | Route of Exposure | Method of Analysis |Route of Exposure | Method of Analysis | Route of Exposure | Method of Analysis |Route of Exposure | Method of Analysis | Route of Exposure | Method of Analysis |Route of Exposure | Method of Analysis | Route of Exposure | Method of Analysis |Route of Exposure | Method of Analysis | Route of Exposure | Method of Analysis |Route of Exposure | Method of Analysis | Route of Exposure | Method of Analysis |Route of Exposure | Method of Analysis | Route of Exposure | Method of Analysis |Route of Exposure | Method of Analysis | Route of Exposure | Method of Analysis |Route of Exposure | Method of Analysis | Route of Exposure | Method of Analysis |Route of Exposure | Method of Analysis | Route of Exposure | Method of Analysis |Route of Exposure | Method of Analysis | Route of Exposure | Method of Analysis |Route of Exposure | Method of Analysis | Route of Exposure | Method of Analysis |Route of Exposure | Method of Analysis | Route of Exposure | Method of Analysis |Route of Exposure | Method of Analysis | Route of Exposure | Method of Analysis |Route of Exposure | Method of Analysis | Route of Exposure | Method of Analysis |Route of Exposure | Method of Analysis | Route of Exposure | Method of Analysis |Route of Exposure | Method of Analysis | Route of Exposure | Method of Analysis |Route of Exposure | Method of Analysis | Route of Exposure | Method of Analysis |Route of Exposure | Method of Analysis | Route of Exposure | Method of Analysis |Route of Exposure | Method of Analysis | Route of Exposure | Method of Analysis |Route of Exposure | Method of Analysis | Route of Exposure | Method of Analysis |Route of Exposure | Method of Analysis | Route of Exposure | Method of Analysis |Route of Exposure | Method of Analysis | Route of Exposure | Method of Analysis |Route of Exposure | Method of Analysis | Route of Exposure | Method of Analysis |Route of Exposure | Method of Analysis | Route of Exposure | Method of Analysis |Route of Exposure | Method of Analysis | Route of Exposure | Method of Analysis |Route of Exposure | Method of Analysis | Route of Exposure | Method of Analysis |Route of Exposure | Method of Analysis | Route of Exposure | Method of Analysis |Route of Exposure | Method of Analysis | Route of Exposure | Method of Analysis |Route of Exposure | Method of Analysis | Route of Exposure | Method of Analysis |Route of Exposure | Method of Analysis | Route of Exposure | Method of Analysis |Route of Exposure | Method of Analysis | Route of Exposure | Method of Analysis |Route of Exposure | Method of Analysis | Route of Exposure | Method of Analysis |Route of Exposure | Method of Analysis | Route of Exposure | Method of Analysis |Route of Exposure | Method of Analysis | Route of Exposure | Method of Analysis |Route of Exposure | Method of Analysis | Route of Exposure | Method of Analysis |Route of Exposure | Method of Analysis | Route of Exposure | Method of Analysis |Route of Exposure | Method of Analysis | Route of Exposure | Method of Analysis |Route of Exposure | Method of Analysis | Route of Exposure | Method of Analysis |Route of Exposure | Method of Analysis | Route of Exposure | Method of Analysis |Route of Exposure | Method of Analysis | Route of Exposure | Method of Analysis |Route of Exposure | Method of Analysis | Route of Exposure | Method of Analysis |Route of Exposure | Method of Analysis | Route of Exposure | Method of Analysis |Route of Exposure | Method of Analysis | Route of Exposure | Method of Analysis |Route of Exposure | Method of Analysis | Route of Exposure | Method of Analysis |Route of Exposure | Method of Analysis | Route of Exposure | Method of Analysis |Route of Exposure | Method of Analysis | Route of Exposure | Method of Analysis |Route of Exposure | Method of Analysis | Route of Exposure | Method of Analysis |Route of Exposure | Method of Analysis | Route of Exposure | Method of Analysis |Route of Exposure | Method of Analysis | Route of Exposure | Method of Analysis |Route of Exposure | Method of Analysis | Route of Exposure | Method of Analysis |Route of Exposure | Method of Analysis | Route of Exposure | Method of Analysis |Route of Exposure | Method of Analysis | Route of Exposure | Method of Analysis |Route of Exposure | Method of Analysis | Route of Exposure | Method of Analysis |Route of Exposure | Method of Analysis | Route of Exposure | Method of Analysis |Route of Exposure | Method of Analysis | Route of Exposure | Method of Analysis |Route of Exposure | Method of Analysis | Route of Exposure | Method of Analysis |Route of Exposure | Method of Analysis | Route of Exposure | Method of Analysis |Route of Exposure | Method of Analysis | Route of Exposure | Method of Analysis |Route of Exposure | Method of Analysis | Route of Exposure | Method of Analysis |Route of Exposure | Method of Analysis | Route of Exposure | Method of Analysis |Route of Exposure | Method of Analysis | Route of Exposure | Method of Analysis |Route of Evaluation: 2007 |
Wildlife TRV Derivation Process

1) There are at least three results available for two test species within the growth, reproduction, and mortality effect groups. There are enough data to derive a TRV.

2) There are at least three NOAEL results available within the growth and reproduction effect groups for calculation of a geometric mean.

3) The geometric mean is equal to 66.1 mg zinc/kg bw/d. This value is lower than the lowest bounded LOAEL for results within the reproduction, growth, and survival (MOR) effect groups.

3) The avian wildlife TRV for zinc is equal to 66.1 mg zinc/kg bw/day which is the geometric mean of NOAEL values for effects on reproduction and growth.
5.2 Estimation of Dose and Calculation of the Eco-SSL

Three separate Eco-SSL values were calculated for avian wildlife, one for each of three surrogate receptor species representing different trophic levels. The avian Eco-SSLs were calculated according to the Eco-SSL guidance (U.S. EPA, 2003) and are summarized in Table 5.2.

<table>
<thead>
<tr>
<th>Surrogate Receptor Group</th>
<th>TRV for Zinc (mg dw/kg bw/d)</th>
<th>Food Ingestion Rate (FIR)</th>
<th>Soil Ingestion as Proportion of Diet (Ps)</th>
<th>Concentration of Zinc in Biota Type (i) (B_i) (mg/kg dw)</th>
<th>Eco-SSL (mg/kg dw)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Avian herbivore (dove)</td>
<td>66.1</td>
<td>0.190</td>
<td>0.139</td>
<td>ln(B_i) = 0.554 * ln(Soil_i) + 1.575 where i = plants</td>
<td>950</td>
</tr>
<tr>
<td>Avian ground insectivore (woodcock)</td>
<td>66.1</td>
<td>0.214</td>
<td>0.164</td>
<td>ln(B_i) = 0.328 * ln(Soil_i) + 4.449 where i = earthworms</td>
<td>46</td>
</tr>
<tr>
<td>Avian carnivore (hawk)</td>
<td>66.1</td>
<td>0.0353</td>
<td>0.057</td>
<td>ln(B_i) = 0.0706 * ln(Soil_i) + 4.3632 where i = mammals</td>
<td>30,000</td>
</tr>
</tbody>
</table>

1 The process for derivation of wildlife TRVs is described in Attachment 4-5 of U.S. EPA (2003).
2 Parameters (FIR, P_i, B_i values, regressions) are provided in U.S. EPA (2003) Attachment 4-1 (revised February 2005).
3 B_i = Concentration in biota type (i) which represents 100% of the diet for the respective receptor.
4 HQ = [FIR * (Soil_i * Ps + B_i)] / TRV solved for HQ=1 where Soil_i = Eco-SSL (Equation 4-2; U.S. EPA, 2003).

6.0 ECO-SSL FOR MAMMALIAN WILDLIFE

The derivation of the Eco-SSL for mammalian wildlife was completed as two parts. First, the TRV was derived according to the Eco-SSL guidance (U.S. EPA, 2003; Attachment 4-5). Second, the Eco-SSL (soil concentration) was back-calculated for each of three surrogate receptor species based on the wildlife exposure model and the TRV (U.S. EPA, 2003).

6.1 Mammalian TRV

The literature search was completed according to the Eco-SSL guidance (U.S. EPA, 2003; Attachment 4-2) and identified 10,410 papers with possible toxicity data for zinc for either avian or mammalian species. Of these studies, 10,259 were rejected for use as described in Section 7.5. Of the remaining papers, 99 contained data for mammalian test species. These papers were reviewed and the data were extracted and scored according to the Eco-SSL guidance (U.S. EPA, 2003; Attachment 4-3 and 4-4). The results of the data extraction and review are summarized in Table 6.1. The complete results are provided as Appendix 6-1.
### Table 6.1: Mammalian Toxicity Data Extracted for Wildlife Toxicity Reference Value (TRV) - Zinc

**Biochemical (BIO)**

<table>
<thead>
<tr>
<th>Result #</th>
<th>Reference</th>
<th>Test Organism</th>
<th>Ref No.</th>
<th>Method of Analysis</th>
<th>Route of Exposure</th>
<th>Exposure Duration</th>
<th>Duration Units</th>
<th>Age</th>
<th>Age Units</th>
<th>Species</th>
<th>Sex</th>
<th>Lifestage</th>
<th>Effect Type</th>
<th>Effect Measure</th>
<th>NOAEL Dose* (mg/kg bw/day)</th>
<th>LOAEL Dose* (mg/kg bw/day)</th>
<th>Total</th>
</tr>
</thead>
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<td>Mink (Mustela vison)</td>
<td>2033</td>
<td>M</td>
<td>FD</td>
<td>4</td>
<td>mo</td>
<td>90</td>
<td>d</td>
<td>JV</td>
<td>M</td>
<td>CHM</td>
<td>MCHC</td>
<td>PL</td>
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<td>20.1</td>
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<td>Van der Schec et al, 1980</td>
<td>Sheep (Ovis aries)</td>
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<td>FD</td>
<td>98</td>
<td>d</td>
<td>NR</td>
<td>NR</td>
<td>JV</td>
<td>M</td>
<td>CHM</td>
<td>HMC</td>
<td>TL</td>
<td>12</td>
<td>66</td>
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</tr>
<tr>
<td>3</td>
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<td>Pig (Sus scrofa)</td>
<td>45278</td>
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<td>FD</td>
<td>4</td>
<td>w</td>
<td>NR</td>
<td>NR</td>
<td>GE</td>
<td>F</td>
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<td>Rat (Rattus norvegicus)</td>
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<td>d</td>
<td>JV</td>
<td>M</td>
<td>CHM</td>
<td>HMC</td>
<td>TL</td>
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<td>Gaynor et al, 1988</td>
<td>Cow (Bos taurus)</td>
<td>47892</td>
<td>M</td>
<td>FD</td>
<td>4</td>
<td>w</td>
<td>NR</td>
<td>NR</td>
<td>LC</td>
<td>F</td>
<td>CHM</td>
<td>PRTL</td>
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<td>2</td>
<td>mo</td>
<td>JV</td>
<td>M</td>
<td>CHM</td>
<td>CALC</td>
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* NOAEL: No Observed Adverse Effect Level

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### Biochemical (BIO)

**No of Conc/ Doses**

**Route of Exposure**

**Exposure Duration**

**Duration Units**

**Age**

**Age Units**

**Species**

**Sex**

**Lifestage**

**Effect Type**

**Effect Measure**

**NOAEL Dose* (mg/kg bw/day)**

**LOAEL Dose* (mg/kg bw/day)**

**Total**

---

**Behavior (BEH)**

**Physiology (PHY)**
Table 6.1 Mammalian Toxicity Data Extracted for Wildlife Toxicity Reference Value (TRV)

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Eco-SSL for Zinc

June 2007
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<td>Settlemire and Matrone, 1967</td>
<td>Rat (Rattus norvegicus)</td>
<td>667</td>
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<tr>
<td>171</td>
<td>Ogiso, et al, 1974</td>
<td>Rat (Rattus norvegicus)</td>
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<td>172</td>
<td>Scott and Magee, 1979</td>
<td>Rat (Rattus norvegicus)</td>
<td>968</td>
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Survival (MOR)

<table>
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<th>Result #</th>
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<th>Test Organism</th>
<th>LOAEL Dose* (mg/kg bw/day)</th>
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<tr>
<td>173</td>
<td>Seidenberg et al, 1986</td>
<td>Mouse (Mus musculus)</td>
<td>8.89</td>
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<td>174</td>
<td>Van der Schee et al, 1980</td>
<td>Sheep (Ovis aries)</td>
<td>12.0</td>
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<tr>
<td>175</td>
<td>Food and Drug Res. Lab, 1973</td>
<td>Mouse (Mus musculus)</td>
<td>12.0</td>
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<td>176</td>
<td>Food and Drug Res. Lab, 1973</td>
<td>Rat (Rattus norvegicus)</td>
<td>42.5</td>
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<tr>
<td>177</td>
<td>Brink et al, 1959</td>
<td>Pig (Sus scrofa)</td>
<td>43.5</td>
</tr>
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<td>178</td>
<td>Food and Drug Res. Lab, 1974</td>
<td>Rabbit (Oryctolagus cuniculus)</td>
<td>60.0</td>
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<tr>
<td>179</td>
<td>Ott et al, 1966</td>
<td>Sheep (Ovis aries)</td>
<td>82.9</td>
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Eco-SSL for Zinc

June 2007
Table 6.1  Mammalian Toxicity Data Extracted for Wildlife Toxicity Reference Value (TRV)

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<th>Result #</th>
<th>Reference</th>
<th>Test Organism</th>
<th>Ref No.</th>
<th># of Conc/ Doses</th>
<th>Method of Analyses</th>
<th>Route of Exposure</th>
<th>Route of Exposure Duration</th>
<th>Exposure Duration</th>
<th>Duration Units</th>
<th>Age</th>
<th>Age Units</th>
<th>Lifestage</th>
<th>Sex</th>
<th>Effect Type</th>
<th>Effect Measure</th>
<th>Response Site</th>
<th>NOAEL Dose* (mg/kg bw/day)</th>
<th>LOAEL Dose* (mg/kg bw/day)</th>
<th>Total</th>
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<td>180</td>
<td>Willoughby et al, 1972</td>
<td>Horse (Equus caballus)</td>
<td>14385</td>
<td>2 M FD 9 w 3-4 w</td>
<td>JV F MOR</td>
<td>MORT</td>
<td>WO</td>
<td>83.7</td>
<td>78</td>
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<tr>
<td>181</td>
<td>Food and Drug Res. Lab, 1973</td>
<td>Hamster (Mesocricetus auratus)</td>
<td>42289</td>
<td>3 U GV 5 d NR NR</td>
<td>GE F</td>
<td>MOR</td>
<td>SURV</td>
<td>WO</td>
<td>88.0</td>
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<tr>
<td>182</td>
<td>Aulerich et al, 1991</td>
<td>Mink (Mustela vison)</td>
<td>46274</td>
<td>4 M FD 144 d &gt;1 yr AD</td>
<td>M</td>
<td>MOR</td>
<td>WO</td>
<td>165</td>
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<td>Aulerich et al, 1991</td>
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<td>46274</td>
<td>4 M FD 144 d 10-12 w</td>
<td>JV M</td>
<td>MOR</td>
<td>WO</td>
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<td>46274</td>
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<td>JV F</td>
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<td>46274</td>
<td>4 M FD 114 d 10-12 w</td>
<td>JV AD</td>
<td>F</td>
<td>MOR</td>
<td>WO</td>
<td>327</td>
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<td>186</td>
<td>Aulerich et al, 1991</td>
<td>Mouse (Mus musculus)</td>
<td>43680</td>
<td>4 U FD 13 w 5 w</td>
<td>JV M</td>
<td>MOR</td>
<td>WO</td>
<td>458</td>
<td>81</td>
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<td>187</td>
<td>Maita et al, 1981</td>
<td>Mouse (Mus musculus)</td>
<td>43680</td>
<td>4 U FD 13 w 5 w</td>
<td>JV M</td>
<td>MOR</td>
<td>WO</td>
<td>4878</td>
<td>79</td>
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<td>188</td>
<td>Maita et al, 1981</td>
<td>Rat (Rattus norvegicus)</td>
<td>43680</td>
<td>4 U FD 13 w 5 w</td>
<td>JV M</td>
<td>MOR</td>
<td>WO</td>
<td>4927</td>
<td>81</td>
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<tr>
<td>189</td>
<td>Maita et al, 1981</td>
<td>Rat (Rattus norvegicus)</td>
<td>43680</td>
<td>4 U FD 13 w 5 w</td>
<td>JV M</td>
<td>MOR</td>
<td>WO</td>
<td>2486</td>
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</tr>
<tr>
<td>190</td>
<td>Maita et al, 1981</td>
<td>Pig (Sus scrofa)</td>
<td>149</td>
<td>2 U FD 10 w NR</td>
<td>NR JV</td>
<td>M</td>
<td>MOR</td>
<td>WO</td>
<td>99.1</td>
<td>78</td>
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<td></td>
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</table>

AD = adult; AHDX = aniline hydroxylase; ALPH = alkaline phosphatase; B = both; BDWT = body weight changes; BEH = behavior; BI = bile; BIO = biochemical; BL = blood; BR = brain; bw = body weight; CALC = calcium; CCOX = cytochrome C-oxidase; CHM = chemical changes; CHOL = cholesterol; d = day; DIFD = digestibility of food; DR = Drinking water; DT = digestive tract; ENZ = enzyme level changes; F = female; FCNS = food consumption; FD = food; FDB = feeding behavior; FDV = food conversion efficiency; FDNG = feeding behavior; FM = femur; FO = foot; GBCM = general biochemical changes; GE = gestation; GGRO = general growth changes; GLPX = glutathione peroxidase; GLSN = gross lesions; GLUC = glucose; GLYC = glycogen; GPHY = general physiology changes; GRO = growth; GREP = general reproduction; GRS = gross body weight changes; GT = gastrointestinal tract; GV = gavage; HA = hair; HE = heart; HEMT = hematocrit; HIS = histological changes; HM = humerus; HMCT = hematocrit; HMG = hemoglobin; HRM = hormone changes; IN = intestinal tract; ITX = intoxication; JV = juvenile; kg = kilograms; KI = kidney; LC = lactation; LD = lipid; LI = liver; LOAEL = lowest observed adverse effect level; mg = milligrams; mo = months; M = male; M = measured; MCHC = mean corpuscular hemoglobin; MCPP = microsomal proteins; MK = milk, lactating females; MOR = effects on mortality and survival; MORT = mortality; MPH = morphology; MT = multiple; MU = muscle; NACO = sodium; NOAEL = No Observed Adverse Effect Level; NCRO = necrosis; NR = Not reported; NMVM = number of movements; ODVP = offspring development; OR = other oral; ORW = organ weight changes; ORWT = organ weight changes; OV = ovary; P450 = cytochrome P450; PCLV = packed cell volume; PCLV = packed cell volume; PLY = physiology; PL = plasma; PRFM = pregnant females in a population; PROG = progeny numbers/counts; PRTL = protein, total; PRWT = progeny weight; PS = pancreas; PTH = pathology; RBCE = red blood cell count; REP = reproduction; RHIS = reproductive organ histology; RSEM = resorbed embryos; SH = stomach; SK = skin; SM = sexually mature; SMIX = weight relative to body weight; SP = spleen; SPCL = sperm cell counts; SR = serum; SURV = survival; TB = tibia; TE = testes; TEWT = testes weight; TS = thymus; TWBC = white blood cell count, total; U = unmeasured; UR = urine; USTR = ultrastructural changes; UD = Vas deferens; VMA = vitamin A; w = weeks; WCON = water consumption; WO = whole organism.

*NOAEL and LOAEL values that are equal and from the same reference represent different experimental designs. These are designated with different Phase numbers in Appendix 6.1.
Within the reviewed papers there are 190 results for biochemical (BIO), behavior (BEH), physiology (PHY), pathology (PTH), reproduction (REP), growth (GRO), and survival (MOR) endpoints with a total Data Evaluation Score >65 that were used to derive the TRV (U.S. EPA 2003; Attachment 4-4). These data are plotted in Figure 6.1 and correspond directly with the data presented in Table 6.1. The NOAEL results for growth and reproduction are used to calculate a geometric mean NOAEL. This geometric mean is examined in relationship to the lowest bounded LOAEL for reproduction, growth, and survival to derive the TRV according to the Eco-SSL guidance (U.S. EPA 2003; Attachment 4-5).

A geometric mean of the NOAEL values for reproduction and growth was calculated at 75.4 mg zinc/kg bw/day. This value is lower than the lowest bounded LOAEL for reproduction, growth, or mortality results. Therefore, the TRV is equal to the geometric mean of the NOAEL values for reproduction and growth and is equal to 75.4 mg zinc/kg bw/day.

### 6.2 Estimation of Dose and Calculation of the Eco-SSL

Three separate Eco-SSL values were calculated for mammalian wildlife, one for each of three surrogate receptor groups representing different trophic levels. The mammalian Eco-SSLs derived for Zinc were calculated according to the Eco-SSL guidance (U.S. EPA, 2003; Attachment 4-5) and are summarized in Table 6.2.

<table>
<thead>
<tr>
<th>Surrogate Receptor Group</th>
<th>TRV for Zinc (mg dw/kg bw/d)</th>
<th>Food Ingestion Rate (FIR) (kg dw/kg bw/d)</th>
<th>Soil Ingestion as Proportion of Diet (P_s)</th>
<th>Concentration of Zinc in Biota Type (i) (mg/kg dw)</th>
<th>Eco-SSL (mg/kg dw)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mammalian herbivore (vole)</td>
<td>75.4</td>
<td>0.0875</td>
<td>0.032</td>
<td>ln(B_i) = 0.554 * ln(Soil_i) + 1.575 where i = plants</td>
<td>6,800</td>
</tr>
<tr>
<td>Mammalian ground insectivore (shrew)</td>
<td>75.4</td>
<td>0.209</td>
<td>0.030</td>
<td>ln(B_i) = 0.328 * ln(Soil_i) + 4.449 where i = earthworms</td>
<td>79</td>
</tr>
<tr>
<td>Mammalian carnivore (weasel)</td>
<td>75.4</td>
<td>0.130</td>
<td>0.043</td>
<td>ln(B_i) = 0.0706 * ln(Soil_i) + 4.3632 where i = mammals</td>
<td>10,000</td>
</tr>
</tbody>
</table>

1 The process for derivation of wildlife TRVs is described in Attachment 4-5 of U.S. EPA (2003).
2 Parameters (FIR, P_s, B_i values, regressions) are provided in U.S. EPA (2003) Attachment 4-1 (revised February 2005).
3 B_i = Concentration in biota type (i) which represents 100% of the diet for the respective receptor.
4 HQ = [FIR * (Soil_i * P_s + B_i)] / TRV solved for HQ=1 where Soil_i = Eco-SSL (Equation 4-2; U.S. EPA, 2003).
Figure 6.1 Mammalian TRV Derivation for Zinc

Wildlife TRV Derivation Process

1) There are at least three results available for two test species within the growth, reproduction, and mortality effect groups. There are enough data to derive a TRV.

2) There are three NOAEL results available within the growth and reproduction effect groups for calculation of a geometric mean.

3) The geometric mean is equal to 75.4 mg zinc/kg bw/d and is lower than the lowest bounded LOAEL for results within the reproduction, growth, and survival (MOR) effect groups.

4) The mammalian wildlife TRV for zinc is equal to 75.4 mg zinc/kg bw/day which is the geometric mean of NOAEL results within the reproduction and growth effect groups.
7.0 REFERENCES

7.1 General Zinc References


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7.2 References for Plants and Soil Invertebrates


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7.3 References Rejected for Use in Deriving Plant and Soil Invertebrate Eco-SSLs
These references were reviewed and rejected for use in derivation of the Eco-SSL. The definition of the codes describing the basis for rejection is provided at the end of the reference sections.


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**Eco-SSL for Zinc**

26 June 2007
of Sewage Sludge on Zinc Content in Soil and Plants. Rostl. Vyroba 44[10], 457 462 (CZE)


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ERE
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<td>ERE</td>
<td>Chlopecka, A. 1993. Forms of Trace Metals from Inorganic Sources in Soils and Amounts Found in Spring Barley. Water Air Soil Pollut. 69[1 2], 127 134</td>
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<td>Chongpraditnun, Praphasri, Mori, Satoshi, and Chino, Mitsuo. 1992. Excess copper induces a cytosolic copper zinc superoxide dismutase in soybean root. Plant Cell Physiol. 33[3], 239 244</td>
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<table>
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<th>Literature</th>
<th>Reference</th>
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<td>McKenna, I. M., Chaney, R. L., and Williams, F. M.</td>
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7.5 References Rejected for Use in Derivation of Wildlife TRV

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Diss  insulin as a regulator of protein-induced hypercalciumria. 1045886 ORDER NO: AAD89-05372

Diss  insulin-induced muscle membrane changes in a rat model for hypokalemic periodic paralysis (inward rectifying, potassium channel, disease). 902588 ORDER NO: AAD85-29889

Not Avail  intake of zinc sulphate in drinking water by grazing beef cattle.|
the interaction of dietary protein and zinc deficiencies with heligmosomoides polygyrus infection in mice. 01464914 ORDER NO: AADAA-IMM00005

interaction of phytic acid and zinc affecting copper bioavailability in rats. 917260 ORDER NO: AAD86-07921

interactions among silicon, copper, zinc, iron and ascorbic acid in the rat. 01482245 ORDER NO: AADAA-I9613050

interactions among zinc, copper, iron, manganese, and ascorbic acid in the Japanese quail (dietary supplements, toxicity, perosis, trace elements, anemia). 887582 ORDER NO: AAD85-14498

interactions of cadmium and zinc during pregnancy. 1046169 ORDER NO: AAD89-06090

interactions of cadmium, copper and zinc in animals chronically to low levels of dietary cadmium. 228157 ORDER NO: AAD60-03727

interrelationship of high zinc and high calcium in the maternal diet on the mineral composition of brain and liver in the newborn, weanling and maternal rat. 392237 ORDER NO: AAD71-06354

an investigation of growth, copper metabolism, and iron metabolism of rats fed high levels of zinc. 228157 ORDER NO: AAD60-03727

investigations of zinc in taste perception, adolescent growth and zinc/fat interrelationships. 785785 ORDER NO: AAD82-17516


isolation and characterization of cDNAs from mammary mRNAs differently expressed in lethal milk mutation mice (zinc deficiency). 01619733 ORDER NO: AAD98-15272


kainic acid-induced hyperalgesia as a model for the study of chronic pain (fibromyalgia syndrome). 01619561 ORDER NO: AAD98-15030

kinetic studies on thermolysin. 771755 ORDER NO: AAD82-04866

a kinetic study of zinc metabolism throughout the life cycle of the mouse. 0978962 ORDER NO: AAD87-29965

lead poisoning in swans cygnus olor. 01268158 ORDER NO: AADDX-93538

lipid metabolism: interaction effects of dietary pectin, phytate, and calcium with zinc and copper (HDL-cholesterol). 823743 ORDER NO: AAD83-21087

mcm2 and mcm3, two homologous proteins with a cell cycle-dependent nuclear localization, are important for ARS function in yeast. 01200167 ORDER NO: AAD92-04082

mechanisms of the zinc protective effects against carbon-tetrachloride hepatotoxicity. 771333 ORDER NO: AAD82-03738

mechanistic and structural studies of mouse adenosine deaminase (charge stabilization, enzyme
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<td>the metabolism of metallothionein in perinatal rat liver.</td>
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<td>mineral metabolism in relation to resistance of the body (ca, na and status in horses, calves and piglets).</td>
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<td>Diss</td>
<td>molecular studies of the phenylalanine-inhibited isozyme of 3-deoxy-d-arabino-heptulosonate 7-phosphate synthase from escherichia coli (dahps(phe)).</td>
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<td>mutations within the ery1 transcriptional unit are associated with juvenile lethality, neuromuscular tremors and germ cell defects in jdf2 mutant mice and pigmentation abnormalities in p(x) and p(m) alleles.</td>
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<td>neuronal plasticity in the hippocampal formation after selective hippocampal cell destruction (sympathetic ingrowth).</td>
<td>839838 <em>ORDER NO: AAD84-07825</em></td>
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<td>Diss</td>
<td>nmr structural studies of the lim domain only proteins: cysteine rich protein and cysteine rich intestinal protein.</td>
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nutrient availability modulating physiology and pathogenicity of legionella pneumophila (iron limitation, zinc metalloprotease, ph dependence). 01626190 ORDER NO: NOT AVAILABLE FROM UNIVERSITY MICROFILMS INT'L.

nutrient interactions of lead and distribution, mobilization and adverse effects of prolonged maternal lead stores. 1040850 ORDER NO: AAD89-03553


do the occurrence and toxicology of heavy metals in chesapeake bay waterfowl (duck, clangula, melanitta, hyemalis, deglandi, anas, platyrhynchos, rubripes, strepera, maryland, virginia). 856378 ORDER NO: AAD83-12307

do of young male rats fed adequate and excess protein. 01090702 ORDER NO: AAD90-05827

do olfactory and photoperiodic mediation of reproduction in the rat (rattus norvegicus). 846785 ORDER NO: AAD84-13535

on the morphology of grain boundary segregation: effect of grain boundary structure in aluminum-zinc alloys.

oral dimercaptosuccinic acid and ongoing exposure to lead (chelation)+. 01391103 ORDER NO: AAD95-02198

do the parameters that influence reproductive success in congeneric strains of house mice. 1045268 ORDER NO: AAD89-00907

do the pathogenesis of chemically induced pancreatic injury pancreatic injury. 01292096 ORDER NO: AAD93-14086

do performance of broilers and layers fed crab meal and other substances for improving utilization of diets containing whey or cellulose. 929314 ORDER NO: AAD86-19225

perinatal and postweaning effects of the interaction between maternal ethanol ingestion and low dietary zinc in the rat (caries). 844602 ORDER NO: AAD84-11475


physiological effects of chitosan and chitorich(tm) on rats fed at two levels of lipid and fiber. 01617028 ORDER NO: AAD13-87791

phytate, phytase, germination and zinc bioavailability from peas (processing, electron microscopy). 904918 ORDER NO: AAD85-27116

post-translational modifications and expression stability of gpi-anchored and secreted forms of a recombinant metalloproteinase (glycosylphosphatidylinositol). 01631287 ORDER NO: AADNQ-25122
Diss  poultry offal as a source of energy and protein in growing-finishing swine diets (lactobacillus acidophilus, silage, viscera, zinc-65).  911526 ORDER NO: AAD86-06096


Unrel  preparation of a fruit nutrient "zengguosu" which can increase fruit production.  Faming Zhuanli Shenqing Gongkai Shuomingshu : 4 pp.


Diss  prevention of cadmium induced immunopathology by zinc in mice.  1057441 ORDER NO: NOT AVAILABLE FROM UNIVERSITY MICROFILMS INT'L.

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Diss  proton transfer in catalysis by the carbonic anhydrases.  01690720 ORDER NO: AAD99-19557

Diss  purification and characterization of pit viper venom components (e toxin, hemorrhagin, crotamine, neurotoxin, rattlesnake).  926840 ORDER NO: AAD86-18067

Diss  purification and properties of rat intestinal peptidyl dipeptidase a.  01159591 ORDER NO: AADDX-92140

HHE  purification, inhibition and mechanistic studies of clostridium histolyticum and human neutrophil collagenases.  929270 ORDER NO: AAD86-19145

Diss  rapid effects of dietary zinc on the epithelium of the small intestine in zinc deficient rats.  01557715 ORDER NO: AADMM-14384

Diss  the rapid effects of dietary zinc on the structure and function of the lower gastrointestinal tract of the rat.  01512429 ORDER NO: AADMM-09652

Diss  reactive synaptogenesis in the dentate gyrus following entorhinal cortex/fimbria fornix transections in adult rats (entorhinal cortex, fimbria fornix).  01408267 ORDER NO: AADAA-I0575709


Diss  regulation of hepatic glutaminase.  1064628 ORDER NO: AAD89-15087

Diss  relationship between the concentration of intracellular divalent cations and excitotoxicity (calcium, magnesium, zinc, glutamate).  01704096 ORDER NO: AAD99-28074

Diss  relative bioavailability of different organic and inorganic zinc and copper sources in ruminants and rats (lysine, methionine).  01469980 ORDER NO: AADAA-I9606713


Diss  reversible chelation of bouton zinc: effects on hippocampal function measured behaviorally.
Diss the role of mouse adenosine deaminase in purine metabolism: physiological and mechanistic aspects. 01409906 ORDER NO: AADAA-I9514209

Diss the role of the main and vomeronasal olfactory systems in the mediation of individual recognition in spiny mice. 922167 ORDER NO: AAD86-16364

Diss role of the vomeronasal organ in murine priming and signalling chemocommunication systems. 738309 ORDER NO: AAD81-03936

Diss scientific basis for the use of cyanobacteria in bioremediation (synechococcus, heavy metals). 01463365 ORDER NO: AADAA-I9606027

Diss the search for a model to define the physiological interaction of zinc and epidermal growth factor in the rat esophagus. 01557776 ORDER NO: AADMM-14458

Unrel SEM and Microprobe Analysis of Bone Response to Zinc-Amalgam Implants. <NOTE> Rept. for Sep 75-Aug 77| AU- Liggett, W. R. ; Brady, J. M. ; Customers); (703)605-6000 (Other Countries); Fax at (703)321-8547; and Email at Orders@Ntis.Fedworld.Gov. NTIS Is Located at 5285 Port Royal Road, Springfield, VA, 22161, USA.

Diss the sensory regulation of maternal aggression in lactating norway rats (rattus norvegicus). 01408840 ORDER NO: AADAA-I9511978

Diss sequential changes in the buccal mucosa of zinc-deficient rats (mucosa).

Diss skeletal development and performance of broilers. 1080439 ORDER NO: AAD89-24144

Diss smooth muscle cells. 01456214 ORDER NO: AADAA-I9601699

Diss isolation and partial characterization of fetal hepatic metallothionein and its role during cadmium exposure in late pregnancy. 754864 ORDER NO: AAD81-18418

Diss some effects of excess dietary zinc on iron-porphyrin compounds in the rat. 099850 ORDER NO: NOT AVAILABLE FROM UNIVERSITY MICROFILMS INT'L.

Diss specificity of transcriptional control in drosophila development (homeodomain). 01212813 ORDER NO: AAD92-10011

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Diss structural determinants of catalysis and steroid binding in 3-alpha-hydroxysteroid dehydrogenase. 01572088 ORDER NO: AAD97-27294


Diss structure and function of the chicken gata-1 transcription factor (zinc fingers, dna binding protein). 01470606 ORDER NO: AADAA-I9607650

Diss studies of age-related testicular and reproductive endocrine toxicity of di-n-butyl phthalate in rats (testicular atrophy). 01164692 ORDER NO: AAD91-19934
Diss studies of select trace element nutrition upon cardiac electrical, morphometrical and ultrastructural aspects of the rat and pig. 01377915 ORDER NO: AAD94-27827

Diss studies of specific ions on chromatin and dna structures (cations). 01351262 ORDER NO: AAD94-11479

Diss studies of the effects of a range of dietary intakes of corn and olive oils and butter upon metabolic responses to endotoxin, in the wistar rat. 01496091 ORDER NO: NOT AVAILABLE FROM UNIVERSITY MICROFILMS INT'L.

Diss studies of the mechanisms of zinc uptake and homeostasis in rat intestine. 804855 ORDER NO: AAD83-05763

Diss studies on intestinal copper and zinc absorption in the rat (perfusion system, basolateral membrane, metallothionein). 882096 ORDER NO: AAD85-10822

Diss studies on the action of pectin and guar gum in growth depression of chicks. 766383 ORDER NO: AAD81-29959

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Diss a study of the human x-linked inhibitory apoptosis protein xiap and its murine homologue miap-3. 01672988 ORDER NO: AADNO-32444

Diss a study of zinc concentration in hair as an indication of zinc imbalances. 755383 ORDER NO: AAD81-19631

Diss sugar alcohols and mineral metabolism: an experimental study of the effect of dietary sugar alcohols on the mineral, electrolyte and acid-base balance of the rat (polyol, xylitol, sorbitol). 1032557 ORDER NO: NOT AVAILABLE FROM UNIVERSITY MICROFILMS INT'L.

Diss synthesis, antineoplastic activity and mode of action of novel styryl ketones. 801525 ORDER NO: NOT AVAILABLE FROM UNIVERSITY MICROFILMS INT'L.

Diss taste dysfunction in zinc-depleted rats. 0956399 ORDER NO: AAD87-12455

Diss teratogenic effect of calcium edetate (ca-edta) in rats and the protective effect of zinc. 768251 ORDER NO: AAD81-29606

Diss test sequencing as an effective approach to isolate cdnas coding for proteins putatively involved in myocardial development. 01505742 ORDER NO: AADMM-07551

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trace element profile of b-16 murine melanoma by particle-induced x-ray emission analysis. 752168 ORDER NO: AAD81-15696


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**No Oral**


**CP**


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**Drug**


**CP**


**Prim**


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**Bio Acc**

**Mineral**

**Mineral**

**No Dose**

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**Plant**


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**Nut def**


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**No Oral**


**Abstract**


**No Dose**


**Abstract**


**CP**

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Mix

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Plant

Aquatic

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Phys

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Nut def


Nut def


Bio Acc


Nut def


Nut def


Nut def


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Nut def


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Drug


FL


FL


Nut def


Nut def


BioX


Phys


FL


Bio Acc


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FL


OAC


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**Bact**

**Bio Acc**

**No Oral**

**FL**

**Drug**

**Unrel**

**HHE**

**CP**

**FL**

**Nut def**

**Nut**

**No Oral**

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**FL**

**FL**

**FL**

**Plant**

**No COC**

**Yeast**

**Nut**

**Drug**

**BioX**

**Diss**

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**FL**


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**FL**


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**Mix**


**Surv**


**FL**

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HHE

CP

No COC

Org Met

Drug

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Nut def

Meth

Acu

Alt
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CP

Nut def

Unrel

HHE
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FL

Abstract

Nut def

In Vit

Nut def

Mix

Nut def

No Oral

No COC

CP

BioX

Nut def

CP

No Oral

Nut


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CP

CP

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Bact

Org Met

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**CP**


**CP**


**CP**


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**FL**


**FL**


**Abstract**


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**CP**


**IMM**

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**Abstract**

**In Vit**

**Alt**

**No COC**

**No COC**

**In Vit**

**No Dose**

**FL**

**No COC**

**No COC**

**Abstract**

**No Tox**

**Alt**


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Alt  Cai, Donglian, Wang, Dekai, Li, Rongjie, and Xu, Qinghua.  effects of zinc on burn healing and
correlation between serum zinc and serum protein and alkaline phosphatase in burned rabbits.  

**Mix**


**Nut def**


**FL**


**CP**


**FL**


**CP**


**Phys**


**No Dose**


**Alt**


**No Dose**


**FL**


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**No COC**


**CP**


**Aquatic**


**Nut**


**FL**


**FL**


**Bio Acc**


**Herp**


**CP**


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Bact


Abstract


Nut def


Nut def


Unrel


Mineral


CP


Abstract


CP


Abstract


No COC


No COC


No Oral


Gene

Carmona, R., Gonzalez-Iriarte, M., Macias, D., Perez-Pomares, J. M., Garcia-Garrido, L., and

**CP**

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**Nut def**


**Nut def**


**CP**


**Bio Acc**


**Phys**


**No COC**


**Unrel**


**FL**


**Nut def**


**Bact**


**CP**


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**No Oral**

**Alt**

**OAC**

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**Diss**

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**Mineral**

**Nut def**

**Prim**

**No Oral**

**No COC**

**Abstract**

**Nut def**

**No Oral**

**Mix**

**Phys**

**CP**

**FL**

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Nut def  

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Nut  

Gene  

Nut def  

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**FL**  

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**Phys**  

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**Nut def**


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**Biom**


**Mineral**


**No COC**


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**Nut def**


**No COC**


**Org Met**


**Rev**


**Rev**


**Rev**


**In Vit**


**CP**

No Oral


Unrel

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Nut def


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Bio Acc


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**CP**

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**Anat**

**Alt**

**Unrel**

**Drug**

**Prim**

**Unrel**

**Anat**

**Phys**

**Abstract**

**No Oral**

**Unrel**

**Nut def**

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**Drug**


**Mix**


**Mix**


**No COC**


**Nut def**


**No COC**


**HHE**


**Unrel**


**Mix**


**No COC**


**Nut**


**No Oral**


**Nut def**


**No Oral**


**Bio Acc**


**HHE**

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**FL**


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**HHE**


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**No Oral**

**CP**

**Nut**

**No Oral**

**Drug**

**Nut def**

**Nut def**

**Nut def**

**No COC**

**OAC**

**Nut def**

**Carcin**

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Fong, L. Y. Y., Ng, W. L., and Newberne, P. M. n-nitrosodimethylamine-induced forestomach


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**Drug**

**Drug**

**FL**

**Food**

**Nut def**

**Unrel**

**CP**

**CP**

**No Oral**

**No COC**

**Unrel**

**In Vit**

**Org Met**

**Rev**

**Abstract**
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CP

Nut def

No Oral

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**Prim**


**No COC**


**Nut**


**In Vit**


**Alt**


**CP**


**Nut def**


**Phys**


**Gene**


**Gene**


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Drug
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**Nut def**


**Alt**


**In Vit**


**No Dose**


**CP**


**FL**


**CP**


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**HHE**


**Mineral**


**FL**

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**Abstract**


**FL**


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**Alt**  

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**FL**  

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CP

Unrel

No Oral

Prim

No Dose

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Mineral

Food

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Drug

No COC
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<td>FL</td>
<td>Grela, E. R., Czech, A., Winiarska, A., and Fiolka, M.</td>
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**Gene**


**Unrel**


**Alt**


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**Nut def**


**In Vit**


**Fate**


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**HHE**


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**Alt**


**CP**


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<td>morphology and distribution of langerhans cells in the epithelium of the digestive and reproductive tracts of cattle.</td>
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**Unrel**


**OAC**


**Mix**


**Drug**


**Drug**


**Nut def**


**Unrel**


**No Oral**


**No COC**


**Gene**


**Abstract**


**No COC**


**Gene**


**CP**


**Surv**


**Prim**

Leek, J. C., Keen, C. L., Vogler, J. B., Golub, M. S., Hurley, L. S., Hendrickx, A. G., and


Abstract Lei, K. Y. dietary copper deficiency effects on cholesterol metabolism in the rat. *FED PROC. Federation Proceedings.* 36 (3). 1977 1151


<table>
<thead>
<tr>
<th>Title</th>
<th>Authors</th>
<th>Abstract/Description</th>
</tr>
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<tbody>
<tr>
<td>Unrel</td>
<td>Leo, Maria Anna, Kim, Cho II, and Lieber, Charles S.</td>
<td>increased vitamin a in esophagus and other...</td>
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**Mix**

**Unrel**

**Unrel**

**FL**

**CP**

**Mineral**

**FL**

**Nut def**

**Drug**

**Nut def**

**Nut def**

**Nut def**

**Nut def**

**Mix**


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**Nut def**

**FL**

**Phys**

**FL**

**FL**

**Unrel**

**Nut def**

**FL**

**Surv**

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### Bio Acc


### Abstract

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### Mineral


### No COC


### Bact


### No Oral


### Nut def


### Nut def


### Nut def


### Nut


### HHE


### Drug


### FL


### No Dur


### CP


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Prim

Nut def

Prim

Nut def

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**Nut def**


**Nut def**


**Drug**


**Bio Acc**


**Abstract**


**Diss**


**Bio Acc**


**Unrel**


**Rev**


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**Abstract**


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**Nut def**


**Nut def**


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**CP**


**Nut def**


**CP**


**Nut def**


**Nut def**


**HHE**


**BioX**


**In Vit**


**In Vit**


**Nut def**


**Nut def**


**Nut def**


**No Oral**


Drug


Nut def


Nut def


Bact


CP


Nut def


Nut def


HHE


HHE


HHE


HHE


Mineral


Mineral


Species


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**CP**  

**Alt**  

**In Vit**  

**Nut def**  

**FL**  

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**CP**  


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Drug

CP

Abstract

Nut def

Nut def

CP

Abstract

In Vit

Gene

Nut def

No COC
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**Phys**


**Ecol**


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**No COC**


**No Oral**


**FL**


**Drug**


**No Oral**


**No COC**


**No COC**


**Nut def**

**IMM**

**CP**

**IMM**

**Alt**

**Nut**

**Nut**

**FL**

**Nut**

**Nut def**

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**CP**

**Nut**

**CP**

**CP**

**Nut def**

**Nut def**

**Abstract**

**Nut def**

**QAC**

**Mix**

**Nut**

**Nut def**

**Bio Acc**

**Nut def**

**CP**

**Nut def**
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**No COC**


**Drug**


**Phys**


**Unrel**


**Phys**


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**CP**

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Fate

Nut def

Sludge

Nut

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Nut def

Drug

No COC

Nut def

No Oral

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In Vit


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FL 

Org Met 

Org Met 

Phys 

Plant 

No COC 

No Oral 

Nut def 

HHE 

Nut def 

Drug 

Mineral 

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Nut def 
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Carcin

Unrel

Nut def

No COC

Drug

No COC

No Oral

In Vit

Nut def

Nut def

Bio Acc

Mineral

Mineral

Gene

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Unrel

Meth

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Nut

Nut

BioX

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Nut def

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QAC

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Unrel

Unrel

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**No Oral**

**Carcin**

**CP**

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Abstract


Meth


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Prim


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Phys


CP


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Abstract


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**Prim**


**Prim**


**FL**


**Unrel**


**FL**


**Unrel**


**FL**


**No COC**


**Nut def**


**Phys**


**Gene**


**Bact**


**Nut def**


**Nut**


**HHE**


**No Dose**


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Bio Acc

Aquatic

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Abstract

Bio Acc

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Unrel

Unrel

Unrel
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Nut def


Nut def


FL


FL


No COC


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CP


FL


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CP


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No COC


No COC


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**No Dose**

**Gene**

**Nut**

**Phys**

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No Oral

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Carcin

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Nut

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**Nut**

**FL**

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**Unrel**

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Unrel

Carcin

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Abstract


Nut


IMM


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Nut


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Diss


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No COC


No COC


Bio Acc


Carcin


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<table>
<thead>
<tr>
<th>Source</th>
<th>Authors</th>
<th>Title</th>
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<th>Pages</th>
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<tr>
<td>Abstract</td>
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<td>resistance to neonatal zinc deficiency in an undesignated strain of mice.</td>
<td>Proceedings of the North Dakota Academy of Science.</td>
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<td>J. Nutr.</td>
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**Plant**


**Phys**


**No COC**


**Fate**


**Unrel**


**Rev**


**No Tox**


**Abstract**


**No Oral**


**Abstract**


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<tr>
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<th>Title</th>
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<tr>
<td>Bio Acc</td>
<td>Rickard, W. H. and Sweany, H. A.</td>
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<td>CONF-750985-I</td>
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**No Tox**

**Nut**

**Abstract**

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**Abstract**

**Abstract**

**Phys**

**Nut def**

**HHE**

**CP**

**Surv**

**Dead**

**Aquatic**


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**Aquatic**

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**BioX**

**Alt**

**Abstract**

**Drug**

**No Dose**

**In Vit**
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**Drug**

**No Dose**

**Fate**

**Fate**

**Fate**

**Gene**

**In Vit**

**FL**

**In Vit**

**Unrel**

**No Oral**

**FL**

**In Vit**

**Drug**


**Abstract**  RUSSELL, J. B. and SCHWARTZ, R.  1987.  effect of tricarballylic acid a non-metabolizable metabolite of trans aconitic acid on magnesium calcium and zinc excretion.  *71ST ANNUAL MEETING OF THE FEDERATION OF AMERICAN SOCIETIES FOR EXPERIMENTAL BIOLOGY*


In Vit


No Oral


No Oral


No COC


No Oral


FL


FL


FL


FL


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FL


FL


Nut


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**No Oral**


**No Oral**


**In Vit**


**Alt**


**Chem Meth**


**Bio Acc**


**FL**


**FL**


**Nut**


**Nut def**


**CP**


**FL**


**Mix**


**Mix**


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**Drug**   
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**BioX**   
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**Unrel**   

**Lead Shot**   

**No Oral**   
Sandrock, B. C., Kern, S. R., and Bryan, S. E.  

**Bio Acc**   
Sandrock, Balzer C., Kern, Sidney R., and Bryan, Sara E.  

**CP**   
Sandstead, H. H.  

**Nut def**   
Sandstead, H. H.  

**Drug**   
Sandstead, H. H.  

**CP**   
Sandstead, H. H., Al-Ubaidi, Y. Y., Halas, E., and Fosmire, G.  

**CP**   
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Nut def

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Uresk, D. USFA Forest Service Rapid City SD. relation of black-tailed prairie dogs and control programs to. FWS Biol Report 13. P8(1)

Urga, Kelbessa, Narasimha, H. V., Sasikala, B. V., and Vishwanatha, S. bioavailability of iron


FL Uyanik, F., Liman, B. C., and Liman, N. 1999. the effects of danofloxacin on some biochemical parameters and liver inbroilers. Turk Veterinerlik Ve Hayvancilik Dergisi 23(Supplement 4):
Eco-SSL for Zinc


FL Vajda, V. Univérsita Veterinarskeho Lekarstva Kosice Slovak Republic. 1998. phase nutrition of calves with acidified milk drink. 1. feed consumption, growth intensity and metabolic parameters of the blood serum according to growth phases. Slovak Veterinary Journal. V. 23(1) P. 36-41.


Fate Van, Barneveld A A and Van Den Hamer C J A. influence of isotope administration mode and of food consumption on absorption and retention of zinc-65 in mice. Nutrition Reports


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physicochemical characterization of soyatoxin, a novel toxic protein isolated from soybeans (glycine max). Archives of Biochemistry and Biophysics 312(2): 357-366.

**Abstract**


**Mineral**


**Mineral**


**Nut**


**Drug**


**Phys**

Vassilev, Peter P., Venkova, Kalina, Pencheva, Nevena, Radomirov, Radomir, and Staneva-Stoytcheva, Dushka. changes in the contractile responses to carbachol and in the inhibitory effects of verapamil and nitrendipine on isolated smooth muscle preparations from rats subchronically exposed to pb2+ and zn2+. Pharmacol. Toxicol. (Copenhagen) (1994) 75(3-4): 129-35

**Org Met**


**Org Met**


**FL**

Vazquez M, H., Hernandez Hernandez, Horacio, Pointron M, P., Terrazas G, A., Rodriguez R, A. D., Serafin L, N., and Frias C, M. C. E-mail hdzhdz@calli. cnb. unam. mx. 1998. [anosmia in parturient ewes, has no effect on milk production and growth rates of the lambs]. <original> la supresion del olfato maternal en ovejas parturientas, no influye sobre la produccion lactea y el crecimiento de sus crias. P. 79

**Unrel**


**Unrel**


**FL**


**No Oral**


**Diss** Verheyen, G., Siau, O., Herremans, M., and Decuyper, E. 1990. [economical longevity of layer chickens]. *<original>* economische levensduur van leghennen. 90 P.

**FL** Verheyen, G. Leuven Univ. Herlelee Belgium Faculty of Agricultural Sciences. Lab. for Physiology of Domestic Animals and Decuyper, E. 1991. egg quality parameters in a second and third laying year as function of the molting age, strain and molting method. *Archiv Fuer Geflucegelkunde. V.* 55(6) P. 275-282


**FL** Viejo, R. E. Universidad Nacional de la Plata Buenos Aires Argentina Fac. de Ciencias Veterinarias. 1991. [copper toxicosis in sheep]. <original> intoxicacion por cobre en el ovino. *Archivos De Medicina Veterinaria. V.* 23(2) P. 109-121


**No COC** Vihan, V. S. and Rai, P. Chandra Shekhar Azad Univ. of Agriculture and Technology Mathura
Campus India Dept. of Medicine. 1985. experimental pregnancy toxaemia in sheep and goats. *Indian Veterinary Journal. V. 62(11) P. 958-963*

**Drug**

**No COC**

**Nut**

**No Dose**

**No Oral**

**Nut def**

**Nut def**

**HHE**

**FL**

**Nut def**

**No COC**

**Phys**

**No COC**
Abstract

Unrel

FL

In Vit

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No COC

CP

FL

FL

No COC

Nut

Mix

Nut def

No COC

Nut def


Eco-SSL for Zinc


Eco-SSL for Zinc  731  June 2007


Nut def  WAKU, K., KUDO, N., and NAKAGAWA, Y.  1987. the effect of zinc deficiency and cadmium administration on fatty acid metabolism in rat liver.  JOINT JAPAN-USA CONGRESS OF PHARMACEUTICAL SCIENCES


Drug

Drug

Drug

Drug

Nut def

Abstract
Walker, R. I., Snyder, S. L., Moniot, J. V., and Sobocinski, P. Z. evidence for participation of platelets and granulocytes in the endo toxin syndrome. *ABSTR ANNU MEET AM SOC MICROBIOL. Abstracts of the Annual Meeting of the American Society for Microbiology. 76. 1976 B61*

No Oral

No Oral

No Oral

No Oral

Abstract

Nut def

Nut

Rev

Nut def
Wallwork, J. C. 1987. appraisal of the methodology and applications for measurement of the zinc
content of blood components as indicators of zinc status. Biological Trace Element Research 12: 335-350.


FL Wang An, Shan Anshan, and Xu Zhenying (Northeast Agricultural Univ., Harbin China Research Section of Animal Nutrition. 1989. effects of calcium and zinc level of ration on growth, biochemical indexes of blood and zinc content of body in leghorn-type chickens. JOURNAL OF NORTHEAST AGRICULTURAL COLLEGE. V. 20(2) P. 146-153

FL Wang An (Northeast Agricultural Coll., Harbin China. 1994. studies on the bioavailability of various zinc sources in broilers. ACTA ZOONUTRIMENTA SINICA. V. 6(1) P. 44-51


An Prod
Wang Jianwen (Laiyang Agricultural Coll., Liaoning China Dept. of Animal Husbandry and Veterinary Medicine, Wang Zhe, and Li Yuyi. 1990. effects of rations with higher level of calcium on growth, hematological parameters and immunity of layer chickens. *Bulletin of Veterinary College of PLA. V. 10(3) P. 280-284*

Org Met

Nut def

Nut def

HHE

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Phys

In Vit

Mineral

FL

Mix

Unrel

FL

Nut def

FL


In Vit  Wasserman, R. H. 1979.*Molecular Mechanisms of the Epithelial Transport of Toxic Metal Ions*,


Abstract WATANABE, T., SHIMADA, T., and ENDO, A. susceptibility of zinc deficient mice to mitomycin c and x-ray. TERATOLOGY 20:169,1979


CP Watkins, K., Southern, L., Craig, W., and Engstrom, M. efficacy of chelated copper and zinc...


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741

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FL  Weigand, E. and Kirchgessner, M.  1944.  use of the isotope dilution method for the estimation of zinc absorption in experimental animals at different ages and with different supplies.  Zeitschrift Fur Tierphysiologie, Tierernahrung Und Futtermittelkunde


| **FL** | Weiss, I. | 1965. [investigations on the problem of the central nervous regulation of the function of alpha cells in the pancreas of the albino rat. i. behavior of zinc contained in the alpha cells of the rat following adrenalectomy and loading with insulin]. *Endokrinologie* 47(3): 183-92. |
| **FL** | Welker, D. and Neupert, G. | 1974. [comparative biological test of polyacrylate and phosphate


Mix WEN, JIANGUO, LI, YULU, and LU, DISHENG. 300. changes of ldh-x activity of seminiferous tubules of mouse testis in acute cadmium poisoning and the protective effect of zinc. HUNAN YIKE DAXUE XUEBAO; 21 (4). 1996. 295-297


Eco-SSL for Zinc

745

June 2007

Fate

Nut def

Nut def

No Oral

Nut def

Surv

Bio Acc

Bio Acc
Wenzel, Christine Institut fur Meereskunde Kiel Germany, Adelung, Dieter, and Theede, Hans. distribution and age-related changes of trace elements in kittiwake. *Sci Total Environ. V193, N1, P13(14)*

Nut def

Nut def

Nut def

FL

Anat

Drug

Mix
Eco-SSL for Zinc

Nut def

CP

Nut def

In Vit

Gene

In Vit

No Oral

Drug

Nut def

No Oral

Drug

Bio Acc

CP

Unrel
Whanger, P. D. and Deagen, J. T. 1991. influence of zinc on copper binding in tissue proteins of...


**Nut def** White, C. L.  1988.  relationship between plasma zinc, angiotensin-converting enzyme, alkaline phosphatase and onset of symptoms of zinc deficiency in the rat.  *Australian Journal of*
Biological Sciences  41(3): 343-56.


Mineral

No Oral

Nut def

Nut def

HHE

Dead

Alt

CP

Unrel

Drug

Abstract

No Dose

CP
Wied, D. de. 1966. inhibitory effect of acth and related peptides on extinction of conditioned avoidance behavior in rats. *Proceedings of the Society for Experimental Biology and Medicine; 122*

Phys

Surv


Wilhelmi, G. and Tanner, K. 1988. [effect of riboflavin (vitamin b2) on spontaneous gonarthrosis


**Unrel** Williams Tracy A, Barnes Kay, Kenny, A. John, Turner Anthony J, and Hooper Nigel M(A).


**Nut def**  Wilson, I. Dodd, McClain, Craig J., and Erlandsen, Stanley L. ileal paneth cells and iga system in rats with severe zinc deficiency: an immunohistochemical and morphological study.  *Histochem. J.*  12(4): 457-71


Windisch, W. and Kirchgessner, M. 1999. quantitative zn exchange of (65)zn labeled adult rats at zn deficiency induced dietary phytate additions. <original> quantitativer zinkumsatz (65)zn markierter adulter ratten wahrend eines durch phytatzulagen induzierten zinkmangels. <original> proceedings of the society of nutrition physiology berichte der gesellschaft fur ernahrungsphysiologie. Proceedings Of The Society Of Nutrition Physiology (Germany) p 114. No. 8


Windisch, W., Kirchgessner, M., <Editors> Anke, M., Meissner, D., and Mills, C. F. 1993. zinc
exchange in adult rats at different zinc supply. 351-355.

**FL**

**Fate**

**Fate**

**Fate**

**Phys**

**Phys**

**Mix**

**CP**

**Mix**

**Mix**

**Unrel**

**No Oral**

**Sed**

**Unrel**
Winick Jeffrey, Abel Ted, Leonard Mark W, Michelson Alan M, Chardon-Loriaux Isabelle,

Drug

Anat

In Vit

Phys

In Vit

FL

Nut def

IMM

CP

Drug

FL

FL

Unrel

Phys


Abstract Woodworth, J. C(A), Tokach, M. D(A), Nelssen, J. L(A), Goodband, R. D(A), and Sawyer, J.

**Abstract**  

**Abstract**  

**Abstract**  

**HHE**  
Worthington-Roberts, B. 1985. the role of nutrition in pregnancy course and outcome. *Journal of Environmental Pathology, Toxicology and Oncology* 5(6)

**Carcin**  

**No Oral**  

**Nut def**  

**Nut def**  

**CP**  

**Nut**  

**No Oral**  

**Unrel**  

**Alt**  

**No Oral**  

**FL**  


**Org Met** Yamaguchi, M. and Gao YingHua (Laboratory of Endocrinology and Molecular Metabolism, Graduate School of Nutritional Sciences University of Shizuoka 52-1 Yada Shizuoka City 422 Japan. 1998. potent effect of zinc acexamate on bone components in the femoral-metaphyseal tissues of elderly female rats. *General Pharmacology. V.* 30(3) P. 423-427


**Mix** Yamaguchi, M. and Sakashita, T. 1986. enhancement of vitamin d3 effect on bone metabolism in

**Acu**

**Drug**

**Acu**

**Acu**

**Acu**

**Mix**

**Org Met**

**No Dose**

**Mix**

**Acu**

**Acu**

**Acu**

**Acu**

**In Vit**

**Gene**

**Biom**


CP  Yamani, K. A. O. Zagazig Univ. Egypt Faculty of Agriculture, Rashwan, A. A., and Magdy, M. M. 1997. effects of copper, zinc and tafla dietary supplementation on broiler performance. the proceedings of the international conference on animal... and health.  P. 457-463


No COC  Yang Ben-Shan, Yamazaki Michikazu, Wan Qin, and Kato Norihsia(A). 1996. comparison of the response of serum ceruloplasmin and cholesterol, and of tissue ascorbic acid, metallothionein, and...
nonprotein sulphydryl in rats to the dietary levels of cystine and cysteine. *Bioscience Biotechnology and Biochemistry* 60(12): 1933-1936.


FL  Yang, Yuexin, Liu, Jianyu, and Cui, Hongmei.  effect of zinc on cadmium-induced fetal damage.  

Acu  Yang, Yuexin, Liu, Jianyu, and Cui, Hongmei.  evaluation study of zinc absorption speed and 

on the transmission of zinc from mother to fetus during pregnancy.  Acta Nutrimenta Sinica 
17(3):  293-297.

FL  Yang Zijun, Cheng Xiangchao (Yuxi Agricultural Training School, Henan China, Wang Zhe, and 
Li Yuyi.  1992.  [acute toxicity effect of high zinc dietary to chickens].  Henan Agricultural 
Sciences.  (No. 5) P. 31-32

FL  Yang Zijun, Wang Zhe, and Li Yuyi (Veterinary Coll. of PLA, Changchun China Teaching and 
Research Section of Internal Medicine.  1992.  effects of dietary calcium and zinc on 
metallothioneine concentration in liver and kidneys of layer chickens.  Bulletin of Veterinary 
College of PLA.  V. 12(3) P. 221-226

Nut  Yano, H., Hirabayashi, M., and Matsui, T.  removal of phytate from soybean improves zinc and 

CP  Yano, Y.  1976. Development of Positron Emitting Radionuclides for Imaging With Improved 
Positron Detectors.  CONF-761060-7; IAEA-SM-210/123

FL  Yao Junhu, Cao Binyun, and Dou Cheng (Northwestern Agricultural Univ., Yangling Shaanxi 
Acta Universitatis Agriculturae Boreali-Occidentalis.  V. 24(4) P. 55-58

Unrel  Yao, X., Perez-Alvarado, G. C., Louis, H. A., Pominis, P., Hatt, C., Summers, M. F., and Beckerle, 
M. C.  1999.  solution structure of the chicken cysteine-rich protein, crp1, a double-lim protein 

Nut def  Yarom, R., Maunder, C., Scripps, M., Hall, T. A., and Dubowitz, V.  1975.  a simplified method 
of specimen preparation for x-ray microanalysis of muscle and blood cells.  Histochemistry 


Abstract  YASUDA, M., NAKAMURA, H., SHIBASAKI, F., HIRAOKA, Y., and OKUDA, H.  
comparison of teratogenicity of cadmium and zinc in the mouse and the medaka fish.  

Carcin  Yasuda, Shinichi, Shimada, Koichiro, and Horie, Shohei.  1988 .  antitumor effects of cis-
diamminedichloroplatinum(ii) against transplantable lung cancer cells of the   rat.  Dokkyo 

system tissues and bones or rats maintained on minerally unbalanced diets.  Kyoto Daigaku 


Eco-SSL for Zinc

Nut def

Nut def

Unrel

Diss

Abstract
Yeoman, R. R. and Curry, J. J. mating behavior and copulation induced ovulation after ablation of specific olfactory structures in the cycling rat. Federation Proceedings. 35 (3). 1976 727

Nut

Phys

Unrel

FL

Nut def

HHE

CP

No COC

Unrel

FL


<table>
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<th>Source</th>
<th>Reference</th>
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</table>

**Mix**


**Diss**

Yu, Shiguang 1957.  copper metabolism and its interactions with dietary iron, zinc, tin and selenium in rats / shiguang yu.  169 p.: ill. ; 24 cm.

**Nut**


**Unrel**


**No Dose**


**No COC**


**FL**


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**CP**


**Nut def**


**Abstract**


**No Oral**


**No COC**


**Unrel**


Drug

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Nut def

No COC

No Control

CP

In Vit

FL

Nut def

FL

Food

Surv

Org Met


Diss Zeid, A. M. M. 1993. effect of some acid mucopolyscharsides on the bio-availability of zinc in rabbits. 93 P.


In Vit Zemel, M. B. and Zemel, P. C. 1985. effects of food gums on zinc and iron solubility following invitro digestion.  Journal Of Food Science 50(2): 547&.


FL Zglobica, A., Wezyk, S., Jamroz, D., and Kupiec, E. 1990. use of different feed antibiotics in

**Unrel**


**Carcin**


**Drug**


**Drug**


**FL**


**FL**


**Unrel**


**FL**


**Gene**


**Nut**


**Diss**

Zhang, Peng.  prophylactic effect of dietary zinc in a laboratory mouse model of swine dysentery / by peng zhang.  i, 65 leaves : ill. ; 28 cm.

**FL**


**IMM**


**Mix**


**Drug**

Zhang, Zhenwen, Sun, Zhong, Xu, Gesheng, Wang, Yongming, and Liu, Li.  the influence of calcium on prevention and treatment of osteoporosis in ovariectomized rats.  *Yingyang Xuebao*


**CP**

**FL**

**Nut def**

**Unrel**

**Abstract**
ZIDENBERG-CHERR, S., ROSENBAUM, J., and KEEN, C. L. 1987. reduced placental transfer of zinc during organogenesis a mechanism underlying fetal alcohol syndrome fas in rats. *71ST ANNUAL MEETING OF THE FEDERATION OF AMERICAN SOCIETIES FOR EXPERIMENTAL BIOLOGY*

**No COC**

**FL**

**FL**

**Mineral**

**Phys**

**In Vit**

**CP**

**Nut**

**HHE**


Zmudzki, J. 1986. [lead toxicity in calves [zinc protoporphyrin, aminolevulinic acid dehydratase activity, in vivo diagnosis and laboratory diagnosis]]. <original> toksykologia olowiu u cielat. 89 P.


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<table>
<thead>
<tr>
<th>Rejection Criteria</th>
<th>Description</th>
<th>Receptor</th>
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<tr>
<td>ABSTRACT (Abstract)</td>
<td>Abstracts of journal publications or conference presentations.</td>
<td>Wildlife Plants and Soil Invertebrates</td>
</tr>
<tr>
<td>ACUTE STUDIES (Acu)</td>
<td>Single oral dose or exposure duration of three days or less.</td>
<td>Wildlife</td>
</tr>
<tr>
<td>AIR POLLUTION (Air P)</td>
<td>Studies describing the results for air pollution studies.</td>
<td>Wildlife Plants and Soil Invertebrates</td>
</tr>
<tr>
<td>ALTERED RECEPTOR (Alt)</td>
<td>Studies that describe the effects of the contaminant on surgically-altered or chemically-modified receptors (e.g., right nephrectomy, left renal artery ligature, hormone implant, etc.).</td>
<td>Wildlife</td>
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<tr>
<td>AQUATIC STUDIES (Aquatic)</td>
<td>Studies that investigate toxicity in aquatic organisms.</td>
<td>Wildlife Plants and Soil Invertebrates</td>
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<tr>
<td>ANATOMICAL STUDIES (Anat)</td>
<td>Studies of anatomy. Instance where the contaminant is used in physical studies (e.g., silver nitrate staining for histology).</td>
<td>Wildlife</td>
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<tr>
<td>BACTERIA (Bact)</td>
<td>Studies on bacteria or susceptibility to bacterial infection.</td>
<td>Wildlife Plants and Soil Invertebrates</td>
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<tr>
<td>BIOACCUMULATION SURVEY (Bio Acc)</td>
<td>Studies reporting the measurement of the concentration of the contaminant in tissues.</td>
<td>Wildlife Plants and Soil Invertebrates</td>
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<tr>
<td>BIOLOGICAL PRODUCT (BioP)</td>
<td>Studies of biological toxicants, including venoms, fungal toxins, Bacillus thuringiensis, other plant, animal, or microbial extracts or toxins.</td>
<td>Wildlife Plants and Soil Invertebrates</td>
</tr>
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<td>BIOMARKER (Biom)</td>
<td>Studies reporting results for a biomarker having no reported association with an adverse effect and an exposure dose (or concentration).</td>
<td>Wildlife</td>
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<tr>
<td>CARCINOGENICITY STUDIES (Carcin)</td>
<td>Studies that report data only for carcinogenic endpoints such as tumor induction. Papers that report systemic toxicity data are retained for coding of appropriate endpoints.</td>
<td>Wildlife Plants and Soil Invertebrates</td>
</tr>
<tr>
<td>CHEMICAL METHODS (Chem Meth)</td>
<td>Studies reporting methods for determination of contaminants, purification of chemicals, etc. Studies describing the preparation and analysis of the contaminant in the tissues of the receptor.</td>
<td>Wildlife Plants and Soil Invertebrates</td>
</tr>
<tr>
<td>CONFERENCE PROCEEDINGS (CP)</td>
<td>Studies reported in conference and symposium proceedings.</td>
<td>Wildlife Plants and Soil Invertebrates</td>
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<tr>
<td>DEAD (Dead)</td>
<td>Studies reporting results for dead organisms. Studies reporting field mortalities with necropsy data where it is not possible to establish the dose to the organism.</td>
<td>Wildlife Plants and Soil Invertebrates</td>
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<tr>
<td>DISSERTATIONS (Diss)</td>
<td>Dissertations are excluded. However, dissertations are flagged for possible future use.</td>
<td>Wildlife</td>
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<tr>
<td>DRUG (Drug)</td>
<td>Studies reporting results for testing of drug and therapeutic effects and side-effects. Therapeutic drugs include vitamins and minerals. Studies of some minerals may be included if there is potential for adverse effects.</td>
<td>Wildlife Plants and Soil Invertebrates</td>
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<tr>
<td>DUPLICATE DATA (Dup)</td>
<td>Studies reporting results that are duplicated in a separate publication. The publication with the earlier year is used.</td>
<td>Wildlife Plants and Soil Invertebrates</td>
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<tr>
<td>ECOLOGICAL INTERACTIONS (Ecol)</td>
<td>Studies of ecological processes that do not investigate effects of contaminant exposure (e.g., studies of “silver” fox natural history; studies on ferrets identified in iron search).</td>
<td>Wildlife, Plants and Soil Invertebrates</td>
</tr>
<tr>
<td>EFFLUENT (Effl)</td>
<td>Studies reporting effects of effluent, sewage, or polluted runoff.</td>
<td>Wildlife, Plants and Soil Invertebrates</td>
</tr>
<tr>
<td>ECOLOGICALLY RELEVANT ENDPOINT (ERE)</td>
<td>Studies reporting a result for endpoints considered as ecologically relevant but is not used for deriving Eco-SSLs (e.g., behavior, mortality).</td>
<td>Plants and Soil Invertebrates</td>
</tr>
<tr>
<td>CONTAMINANT FATE/METABOLISM (Fate)</td>
<td>Studies reporting what happens to the contaminant, rather than what happens to the organism. Studies describing the intermediary metabolism of the contaminant (e.g., radioactive tracer studies) without description of adverse effects.</td>
<td>Wildlife, Plants and Soil Invertebrates</td>
</tr>
<tr>
<td>FOREIGN LANGUAGE (FL)</td>
<td>Studies in languages other than English.</td>
<td>Wildlife, Plants and Soil Invertebrates</td>
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<tr>
<td>FOOD STUDIES (Food)</td>
<td>Food science studies conducted to improve production of food for human consumption.</td>
<td>Wildlife</td>
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<td>FUNGUS (Fungus)</td>
<td>Studies on fungus.</td>
<td>Wildlife, Plants and Soil Invertebrates</td>
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<tr>
<td>GENE (Gene)</td>
<td>Studies of genotoxicity (chromosomal aberrations and mutagenicity).</td>
<td>Wildlife, Plants and Soil Invertebrates</td>
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<tr>
<td>HUMAN HEALTH (HHE)</td>
<td>Studies with human subjects.</td>
<td>Wildlife, Plants and Soil Invertebrates</td>
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<tr>
<td>IMMUNOLOGY (IMM)</td>
<td>Studies on the effects of contaminants on immunological endpoints.</td>
<td>Wildlife, Plants and Soil Invertebrates</td>
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<tr>
<td>INVERTEBRATE (Invert)</td>
<td>Studies that investigate the effects of contaminants on terrestrial invertebrates are excluded.</td>
<td>Wildlife</td>
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<tr>
<td>IN VITRO (In Vit)</td>
<td>In vitro studies, including exposure of cell cultures, excised tissues and/or excised organs.</td>
<td>Wildlife, Plants and Soil Invertebrates</td>
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<tr>
<td>LEAD SHOT (Lead shot)</td>
<td>Studies administering lead shot as the exposure form. These studies are labeled separately for possible later retrieval and review.</td>
<td>Wildlife</td>
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<tr>
<td>MEDIA (Media)</td>
<td>Authors must report that the study was conducted using natural or artificial soil. Studies conducted in pore water or any other aqueous phase (e.g., hydroponic solution), filter paper, petri dishes, manure, organic or histosoils (e.g., peat muck, humus), are not considered suitable for use in defining soil screening levels.</td>
<td>Plants and Soil Invertebrates</td>
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<td>METHODS (Meth)</td>
<td>Studies reporting methods or methods development without usable toxicity test results for specific endpoints.</td>
<td>Wildlife, Plants and Soil Invertebrates</td>
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<tr>
<td>MINERAL REQUIREMENTS (Mineral)</td>
<td>Studies examining the minerals required for better production of animals for human consumption, unless there is potential for adverse effects.</td>
<td>Wildlife</td>
</tr>
<tr>
<td>MIXTURE (Mix)</td>
<td>Studies that report data for combinations of single toxicants (e.g. cadmium and copper) are excluded. Exposure in a field setting from contaminated natural soils or waste application to soil may be coded as Field Survey.</td>
<td>Wildlife, Plants and Soil Invertebrates</td>
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<td>MODELING (Model)</td>
<td>Studies reporting the use of existing data for modeling, i.e., no new organism toxicity data are reported. Studies which extrapolate effects based on known relationships between parameters and adverse effects.</td>
<td>Wildlife Plants and Soil Invertebrates</td>
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<tr>
<td>NO CONTAMINANT OF CONCERN (No COC)</td>
<td>Studies that do not examine the toxicity of Eco-SSL contaminants of concern.</td>
<td>Wildlife Plants and Soil Invertebrates</td>
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<td>NO CONTROL (No Control)</td>
<td>Studies which lack a control or which have a control that is classified as invalid for derivation of TRVs.</td>
<td>Wildlife Plants and Soil Invertebrates</td>
</tr>
<tr>
<td>NO DATA (No Data)</td>
<td>Studies for which results are stated in text but no data is provided. Also refers to studies with insufficient data where results are reported for only one organism per exposure concentration or dose (wildlife).</td>
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<tr>
<td>NO DOSE or CONC (No Dose)</td>
<td>Studies with no usable dose or concentration reported, or an insufficient number of doses/concentrations are used based on Eco-SSL SOPs. These are usually identified after examination of full paper. This includes studies which examine effects after exposure to contaminant ceases. This also includes studies where offspring are exposed in utero and/or lactation by doses to parents and then after weaning to similar concentrations as their parents. Dose cannot be determined.</td>
<td>Wildlife Plants and Soil Invertebrates</td>
</tr>
<tr>
<td>NO DURATION (No Dur)</td>
<td>Studies with no exposure duration. These are usually identified after examination of full paper.</td>
<td>Wildlife Plants and Soil Invertebrates</td>
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<tr>
<td>NO EFFECT (No Efct)</td>
<td>Studies with no relevant effect evaluated in a biological test species or data not reported for effect discussed.</td>
<td>Wildlife Plants and Soil Invertebrates</td>
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<tr>
<td>NO ORAL (No Oral)</td>
<td>Studies using non-oral routes of contaminant administration including intraperitoneal injection, other injection, inhalation, and dermal exposures.</td>
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<tr>
<td>NO ORGANISM (No Org) or NO SPECIES</td>
<td>Studies that do not examine or test a viable organism (also see in vitro rejection category).</td>
<td>Wildlife Plants and Soil Invertebrates</td>
</tr>
<tr>
<td>NOT AVAILABLE (Not Avail)</td>
<td>Papers that could not be located. Citation from electronic searches may be incorrect or the source is not readily available.</td>
<td>Wildlife Plants and Soil Invertebrates</td>
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<tr>
<td>NOT PRIMARY (Not Prim)</td>
<td>Papers that are not the original compilation and/or publication of the experimental data.</td>
<td>Wildlife Plants and Soil Invertebrates</td>
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<tr>
<td>NO TOXICANT (No Tox)</td>
<td>No toxicant used. Publications often report responses to changes in water or soil chemistry variables, e.g., pH or temperature. Such publications are not included.</td>
<td>Wildlife Plants and Soil Invertebrates</td>
</tr>
<tr>
<td>NO TOX DATA (No Tox Data)</td>
<td>Studies where toxicant used but no results reported that had a negative impact (plants and soil invertebrates).</td>
<td>Plants and Soil Invertebrates</td>
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<tr>
<td>NUTRIENT (Nutrient)</td>
<td>Nutrition studies reporting no concentration related negative impact.</td>
<td>Plants and Soil Invertebrates</td>
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<tr>
<td>NUTRIENT DEFICIENCY (Nut def)</td>
<td>Studies of the effects of nutrient deficiencies. Nutritional deficient diet is identified by the author. If reviewer is uncertain then the administrator should be consulted. Effects associated with added nutrients are coded.</td>
<td>Wilderness Plants and Soil Invertebrates</td>
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<tr>
<td>NUTRITION (Nut)</td>
<td>Studies examining the best or minimum level of a chemical in the diet for improvement of health or maintenance of animals in captivity.</td>
<td>Wilderness Plants and Soil Invertebrates</td>
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<tr>
<td>OTHER AMBIENT CONDITIONS (OAC)</td>
<td>Studies which examine other ambient conditions: pH, salinity, DO, UV, radiation, etc.</td>
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## Literature Rejection Categories

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<th>Rejection Criteria</th>
<th>Description</th>
<th>Receptor</th>
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<tr>
<td><strong>OIL</strong> (Oil)</td>
<td>Studies which examine the effects of oil and petroleum products.</td>
<td>Wildlife Plants and Soil Invertebrates</td>
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<tr>
<td><strong>OM, pH</strong> (OM, pH)</td>
<td>Organic matter content of the test soil must be reported by the authors, but may be presented in one of the following ways; total organic carbon (TOC), particulate organic carbon (POC), organic carbon (OC), coarse particulate organic matter (CPOM), particulate organic matter (POM), ash free dry weight of soil, ash free dry mass of soil, percent organic matter, percent peat, loss on ignition (LOI), organic matter content (OMC). With the exception of studies on non-ionizing substances, the study must report the pH of the soil, and the soil pH should be within the range of $4$ and $8.5$. Studies that do not report pH or report pH outside this range are rejected.</td>
<td>Plants and Soil Invertebrates</td>
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<tr>
<td><strong>ORGANIC METAL</strong> (Org Met)</td>
<td>Studies which examine the effects of organic metals. This includes tetraethyl lead, triethyl lead, chromium picolinate, phenylarsonic acid, roxarsone, 3-nitro-4-phenylarsonic acid, zinc phosphate, monomethylarsonic acid (MMA), dimethylyarsinic acid (DMA), trimethylarsine oxide (TMAO), or arsenobetaine (AsBe) and other organo metallic fungicides. Metal acetates and methionines are not rejected and are evaluated.</td>
<td>Wildlife</td>
</tr>
<tr>
<td><strong>LEAD BEHAVIOR OR HIGH DOSE MODELS</strong> (Pb Behav)</td>
<td>There are a high number of studies in the literature that expose rats or mice to high concentrations of lead in drinking water (0.1, 1 to 2% solutions) and then observe behavior in offspring, and/or pathology changes in the brain of the exposed dam and/or the progeny. Only a representative subset of these studies were coded. Behavior studies examining complex behavior (learned tasks) were also not coded.</td>
<td>Wildlife</td>
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<tr>
<td><strong>PHYSIOLOGY STUDIES</strong> (Phys)</td>
<td>Physiology studies where adverse effects are not associated with exposure to contaminants of concern.</td>
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<tr>
<td><strong>PLANT</strong> (Plant)</td>
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<tr>
<td><strong>PRIMATE</strong> (Prim)</td>
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<tr>
<td><strong>PUBL AS</strong> (Publ as)</td>
<td>The author states that the information in this report has been published in another source. Data are recorded from only one source. The secondary citation is noted as Publ As.</td>
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<tr>
<td><strong>QSAR</strong> (QSAR)</td>
<td>Derivation of Quantitative Structure-Activity Relationships (QSAR) is a form of modeling. QSAR publications are rejected if raw toxicity data are not reported or if the toxicity data are published elsewhere as original data.</td>
<td>Wildlife Plants and Soil Invertebrates</td>
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<tr>
<td><strong>REGULATIONS</strong> (Reg)</td>
<td>Regulations and related publications that are not a primary source of data.</td>
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</tr>
<tr>
<td><strong>REVIEW</strong> (Rev)</td>
<td>Studies in which the data reported in the article are not primary data from research conducted by the author. The publication is a compilation of data published elsewhere. These publications are reviewed manually to identify other relevant literature.</td>
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<td>Receptor</td>
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<td>SEDIMENT CONC</td>
<td>Studies in which the only exposure concentration/dose reported is for the level of a toxicant in sediment.</td>
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<tr>
<td>SCORE</td>
<td>Papers in which all studies had data evaluation scores at or lower then the acceptable cut-off (#10 of 18) for plants and soil invertebrates.</td>
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<td>SLUDGE</td>
<td>Studies on the effects of ingestion of soils amended with sewage sludge.</td>
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</tr>
<tr>
<td>SOIL CONC</td>
<td>Studies in which the only exposure concentration/dose reported is for the level of a toxicant in soil.</td>
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<tr>
<td>SPECIES</td>
<td>Studies in which the species of concern was not a terrestrial invertebrate or plant or mammal or bird.</td>
<td>Plants and Soil Invertebrates Wildlife</td>
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<tr>
<td>STRESSOR</td>
<td>Studies examining the interaction of a stressor (e.g., radiation, heat, etc.) and the contaminant, where the effect of the contaminant alone cannot be isolated.</td>
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<tr>
<td>SURVEY</td>
<td>Studies reporting the toxicity of a contaminant in the field over a period of time. Often neither a duration nor an exposure concentration is reported.</td>
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<tr>
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<td>REPTILE OR AMPHIBIAN</td>
<td>Studies on reptiles and amphibians. These papers flagged for possible later review.</td>
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<tr>
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<td>UNRELATED</td>
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<td>WATER QUALITY STUDY</td>
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<td>YEAST</td>
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Appendix 5-1

Avian Toxicity Data Extracted and Reviewed for Wildlife Toxicity Reference Value (TRV) - Zinc

June 2007
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Appendix 5.1 Avian Toxicity Data Extracted for Wildlife Toxicity Reference Value (TRV)  
Zinc  
Page 1 of 5
### Appendix 5.1 Avian Toxicity Data Extracted for Wildlife Toxicity Reference Value (TRV)

#### Zinc

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<thead>
<tr>
<th>Ref</th>
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<th>Reference</th>
<th>Chemical Form</th>
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<th>Sex</th>
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<th>NOAEL Dose (mg/kg/day)</th>
<th>LOAEL Dose (mg/kg/day)</th>
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Eco-SSL, for Zinc

June 2007
### Appendix 5.1 Avian Toxicity Data Extracted for Wildlife Toxicity Reference Value (TRV)

**Zinc**

**Page 3 of 5**

<table>
<thead>
<tr>
<th>Ref</th>
<th>Test Species</th>
<th>Conc/Dose Units</th>
<th>Age Units</th>
<th>Lifestage</th>
<th>Control Type</th>
<th>Endpoint Number</th>
<th>Effect Type</th>
<th>Study LOAEL</th>
<th>Total Ingestion Rate Reported?</th>
<th>Exposure Duration</th>
<th>Dose Route</th>
<th>Endpoint</th>
<th>Dose Range</th>
<th>NOAEL Dose (mg/kg/day)</th>
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<td>FD</td>
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<td>1 d</td>
<td>JV</td>
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Eco-SSL for Zinc

June 2007
## Appendix 5.1 Avian Toxicity Data Extracted for Wildlife Toxicity Reference Value (TRV)

### Zinc

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<th>Dose Units</th>
<th>Duration Units</th>
<th>Age Units</th>
<th>Lifestage</th>
<th>Control Type</th>
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Eco-SSL for Zinc
June 2007
### Appendix 5.1 Avian Toxicity Data Extracted for Wildlife Toxicity Reference Value (TRV)

**Zinc**

Page 5 of 5

| Ref | MW% | Test Species | Phase # | # of Conc/Doses | Conc/Doses Units | Wet Weight Reported? | Percent Moisture | Application Frequency | Method of Analyses | Route of Exposure | Exposure Duration | Duration Units | Age | Age Units | Lifestage | Sex | Control Type | Endpoint Number | General Effect Group | Effect Type | Effect Measure | Response Site | Study NOAEL | Study LOAEL | Body Weight Reported? | Body Weight in kg | Ingestion Rate Reported? | Ingestion Rate in kg/day or L/day | NOAEL Dose (mg/kg/day) | LOAEL Dose (mg/kg/day) | Data Source | Dose Route | Test Concentrations | Chemical form | Dose Quantification | Endpoint | Dose Range | Statistical Power | Exposure Duration | Test Conditions | Total |
|-----|------|--------------|---------|----------------|-----------------|--------------------|---------------------|---------------------|--------------------|-----------------|-----------------|-----------------|----------------|---------|------------|-----------|------|--------------|-----------------|----------------|----------------|----------------|-------------|-------------|----------------------|------------|---------------------|------------------|-----------------|------------------|------------------|---------------|----------------|-----------------|------------------|------------------|------------------|-------|
| 217 | 5903 | 6442 4 and Cofrde, 1988 | Zinc oxide | 100 | Chicken (Gallus domesticus) | 3 | 10 | 0/200/300/400/500/600/800/1000 mg/kg diet | N | N | ADL | U | FD | 14 d | 1 d | JV | NR | C | 1 | BIO | ENZ | GENZ | PS | 1000 | N | 0.328 | N | 0.02817 | 85.9 | 10 | 4 | 10 | 4 | 55514 | 1 | 0 | 1 | 0 | 4 | 6 | 4 |
| 218 | 5868 | 6442 Blalock and Hill, 1988 | Zinc oxide | 100 | Chicken (Gallus domesticus) | 1 | 3 | 0/1000/2000 mg/kg diet | N | N | ADL | U | FD | 12 d | 1 d | JV | F | C | 3 | BIO | CHM | HMGL | BL | 1000 | Y | 0.164 | N | 0.01794 | 109 | 10 | 10 | 10 | 10 | 55614 | 1 | 0 | 1 | 0 | 4 | 6 | 5 |
| 219 | 7245 | 6442 Sandoval et al, 1998 | Zinc acetate | 100 | Chicken (Gallus domesticus) | 2 | 2 | 0/1000 mg/kg diet | N | N | ADL | U | FD | 1 w | 1 d | JV | F | C | 1 | BIO | CHM | MCPR | LI | 1000 | N | 0.084 | N | 0.0116 | 138 | 10 | 10 | 10 | 10 | 55514 | 1 | 0 | 1 | 0 | 4 | 6 | 4 |
| 220 | 93 | 6442 Berg and Martinson, 1972 | Zinc Oxide | 100 | Chicken (Gallus domesticus) | 1 | 2 | 0/2000 mg/kg diet | N | N | ADL | U | FD | 2 w | 1 d | JV | NR | C | 2 | BIO | CHM | ASHC | BO | 2000 | Y | 0.109 | N | 0.01375 | 252 | 10 | 10 | 10 | 10 | 55614 | 1 | 0 | 1 | 0 | 4 | 6 | 5 |
| 221 | 5619 | 6442 Pimentel et al, 1992 | Zinc | 100 | Chicken (Gallus domesticus) | 1 | 2 | 0/2052.62 mg/kg diet | N | N | ADL | U | FD | 21 d | 1 d | JV | B | C | 1 | BIO | CHM | HMGL | BL | 2052.6 | N | 0.0397 | N | 0.00712 | 368 | 10 | 10 | 10 | 10 | 54514 | 1 | 0 | 1 | 0 | 4 | 6 | 3 |
| 222 | 1624 | 6442 Wight et al, 1986 | Zinc oxide | 100 | Chicken (Gallus domesticus) | 1 | 2 | 0/20000 mg/kg diet | N | N | ADL | U | FD | 5 d | NR | SM | F | C | 2 | BIO | CHM | GBCM | SG | 20000 | N | 1.3 | N | 0.0336 | 517 | 10 | 10 | 10 | 10 | 55614 | 1 | 0 | 1 | 0 | 4 | 6 | 5 |
| 223 | 6435 | 6442 Rama and Planas, 1981 | Zinc | 100 | Chicken (Gallus domesticus) | 1 | 2 | 0/5000 mg/kg diet | N | N | ADL | U | FD | 2 s | 1 d | JV | NR | C | 2 | BIO | CHM | HMGL | BL | 5000 | Y | 0.075 | N | 0.01078 | 719 | 10 | 10 | 10 | 10 | 54614 | 1 | 0 | 1 | 0 | 4 | 6 | 4 |
| 224 | 6144 | 6442 Berry and Brake, 1985 | Zinc oxide | 100 | Chicken (Gallus domesticus) | 1 | 2 | 0/20000 mg/kg diet | N | N | ADL | U | FD | 4 d | 60 w | AD | F | C | 1 | GRO | GRO | BDWT | WO | 20000 | N | 1.6 | N | 0.07903 | 988 | 10 | 10 | 10 | 10 | 55614 | 1 | 0 | 1 | 0 | 4 | 6 | 5 |
| 225 | 7089 | 6442 Berry and Brake, 1990 | Zinc oxide | 100 | Chicken (Gallus domesticus) | 1 | 2 | 0/2 % in diet | N | N | ADL | U | FD | 49 d | 66 w | LB | F | C | 3 | BIO | CHM | GBCM | SG | 2 | N | 1.6 | N | 0.07903 | 988 | 10 | 10 | 10 | 10 | 55614 | 1 | 0 | 1 | 0 | 4 | 6 | 4 |
| 226 | 8181 | 6442 Berry et al., 1987 | Zinc oxide | 100 | Chicken (Gallus domesticus) | 2 | 3 | 0/20000 mg/kg diet | N | N | ADL | U | FD | 4 d | 1 yr | AD | F | C | 1 | BIO | CHM | PCLV | BL | 20000 | N | 1.6 | N | 0.07903 | 988 | 10 | 10 | 10 | 10 | 55614 | 1 | 0 | 1 | 0 | 4 | 6 | 5 |

All abbreviations and definitions are used in coding studies are available from Attachment 4-3 of the Eco-SSL guidance (U.S. EPA 2003).

Duplicate values for NOAELs and LOAELs for the same reference represent results from different experimental designs and are identified by different Phase numbers.

Eco-SSL for Zinc

June 2007
Appendix 6-1

*Mammalian Toxicity Data Extracted and Reviewed for Wildlife Toxicity Reference Value (TRV) - Zinc*

*June 2007*
<table>
<thead>
<tr>
<th>Ref.</th>
<th>Species</th>
<th>Toxicity Route</th>
<th>Toxicity Value</th>
<th>Source</th>
<th>General Effect Group</th>
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Eco-SSL for Zinc

Appendix 6.1  Mammalian Toxicity Data Extracted for Wildlife Toxicity Reference Value (TRV)

Page 1 of 5

June 2007
### Appendix 6.1 Mammalian Toxicity Data Extracted for Wildlife Toxicity Reference Value (TRV)

**Zinc**

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**Eco-SSL for Zinc**

June 2007
Appendix 6.1 Mammalian Toxicity Data Extracted for Wildlife Toxicity Reference Value (TRV)
Zinc
Page 3 of 5

Eco-SSL for Zinc

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BDWT
BDWT
BDWT
GGRO
BDWT
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WO
WO
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Y
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Y
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261
379
379
0.126
134
0.145
91
0.3742
84
0.23
0.25
0.216
1.9
0.2779
0.0415
0.267
623.2
626.2
0.275
0.319
0.269
47.99915
565
0.1728
3.21
0.1131
0.2562
61.3
7.4
7.82
0.000042
0.43
3
0.134
0.0453
0.252
0.0446
0.438
0.0205
0.019
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0.231
0.1838
74.4
0.198
34
0.3945
64.92

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6.659402
9.048949
9.048949
0.0081
2.75
0.0140476
2.11
0.045
2.622493
0.018
0.0219818
0.019493
0.1164373
0.0201
0.0050233
0.0232033
15.1
15
0.0237732
0.0268579
0.023346
2.09
18
0.0162262
0.1791859
0.0114526
0.0224289
2.02418
0.26
0.34
0.0000191
0.0236
0.1694925
0.0131655
0.006
0.0237
0.00416
0.034853
0.0028133
0.002643
0.0027568
0.002412
0.0142
0.0149
0.008
1.2
0.01395
1.246902
0.0319821
1.446

5000

0.2

2514

4927
4878

20

200
1000
400
2065
1000
4000

4.33
4.78
4.78
9.64
10.3
11.7
13.5
14.4
14.9
15.7
15.7
18.0
20.2
28.9
30.0
30.4
30.6
33.2
34
42.1
42.5
43.5
63.7
56
60.0
88.0
97.5
99.1
103
106
110
234
282
295
458
470
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Total

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Test Conditions

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Exposure Duration

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Statistical Power

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7-9
18
18
NR
7-8
NR
6-8
105
NR
NR
NR
9-10
90
40
NR
3
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23
23
12
5
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NR
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NR
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4
NR
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NR
NR
NR
1
NR
4

Dose Range

JV M
JV F
JV F
JV M
GE F
JV M
JV B
LC F
JV B
JV M
JV M
SM M
JV M
JV F
GE F
JV M
LC F
LC F
GE F
JV F
GE F
JV NR
LC F
JV M
GE F
GE F
GE F
JV M
JV B
JV B
JV M
JV M
JV B
JV M
JV M
LC F
JV F
JV M
JV F
JV F
JV F
JV B
JV M
JV F
JV F
SM M
JV M
JV M
GE F
JV NR

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Endpoint

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50
5
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12
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37
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42
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0.0313209
0.0319821
0.0204523
0.0313209
0.0313209
0.0216198
0.0092483

12.2
81.1
232
326
326
353
424

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10 4 83
10 4 78
10 4 69
10 4 73
3 4 71
10 4 73
10 4 81
10 4 71
10 4 73

103

87.1

2514

4927
4878

2838

8.71
16.1
28.2
75.7
81.1
89.1

Dose Quantification

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Chemical form

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0.3846
0.3945
0.229
0.3846
0.3846
0.245
0.0872

Test Concentrations

ADL
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NR
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3 per d
ADL
ADL

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Dose Route

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150
1000
232
4000
0.4
0.4
0.4

Data Source

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WO
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WO
WO

Data Evaluation Score

LOAEL Dose (mg/kg/day)

0/460.28/527.70/1072.50/1129.26 mg/org/d
0/200
mg/kg diet
0/200
mg/kg diet
0/150
mg/kg diet
0/500/5000
mg/kg diet
0/444/789/1701
ug/org/d
0/581
mg/kg diet
0/120
mg/kg diet
0/478
mg/kg diet
0/200
mg/kg diet
0/0.44
g/kg diet
0/200
mg/kg diet
0/171/330
mg/kg diet
0/400
mg/kg diet
0/6.5/30.0
mg/kg bw/d
0/350
mg/kg diet
0/1264.0
mg/kg diet
0/1386.4
mg/kg diet
0/34
mg/kg bw/d
0/500
mg/kg diet
0/2.0/9.1/42.5
mg/kg bw/d
0/0.05/0.10/0.20/0.40/0.80
% in diet
0/1000/2000
mg/kg diet
0/56
mg/kg bw/d
0/0.6/2.8/13.0/60.0
mg/kg bw/d
0/4.1/19.0/88.0
mg/kg bw/d
0/0.09746
mg/g bw
0/3000
mg/kg diet
0/236/572/762
mg/d
0/218/624/830
mg/d
0/110.2
mg/kg bw/d
0/23.2/234/2514
mg/kg bw/d
0/1000/5000
ug/g
0/3000
mg/kg diet
0/42.7/458/4927
mg/kg bw/d
0/0.2/0.5
% in diet
0/46.4/479/4878
mg/kg bw/d
0/0.75
% in diet
0/6010
mg/kg diet
0/6075
mg/kg diet
0/6135
mg/kg diet
0/10/20
g/kg diet
0/30
mg/g diet
0/24.5/243/2486
mg/kg bw/d
0/200
ug/g
0/1000
mg/kg diet
0/400
mg/kg diet
0/2065
mg/kg diet
0/1000
mg/kg diet
0/4000
mg/kg diet

RSEM
PROG
PROG
GREP
PRWT
PRWT
PRWT

NOAEL Dose (mg/kg/day)

5
2
2
2
3
4
2
2
2
2
2
2
3
2
3
2
2
2
2
2
4
6
3
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5
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2

REP
REP
REP
REP
REP
REP
REP

Ingestion Rate in kg or L/day

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1
2
1
1
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1
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4
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1

REP
REP
REP
REP
REP
REP
REP

Ingestion Rate Reported?

Water buffalo (Bubalus bubalis )
Cattle (Bos taurus )
Cattle (Bos taurus )
Rat (Rattus norvegicus )
Pig (Sus scrofa )
Rat (Rattus norvegicus )
Pig (Sus scrofa )
Rat (Rattus norvegicus )
Pig (Sus scrofa )
Rat (Rattus norvegicus )
Rat (Rattus norvegicus )
Rat (Rattus norvegicus )
Mink (Mustela vison )
Rat (Rattus norvegicus )
Mouse (Mus musculus )
Rat (Rattus norvegicus )
Cattle (Bos taurus )
Cattle (Bos taurus )
Rat (Rattus norvegicus )
Rat (Rattus norvegicus )
Rat (Rattus norvegicus )
Pig (Sus scrofa )
Cattle (Bos taurus )
Rat (Rattus norvegicus )
Rabbit (Oryctolagus cuniculus )
Hamster (Mesocricetus auratus )
Rat (Rattus norvegicus )
Pig (Sus scrofa )
Pig (Sus scrofa )
Pig (Sus scrofa )
Mouse (Mus musculus )
Rat (Rattus norvegicus )
Rabbit (Oryctolagus cuniculus )
Golden hamster (Mesocricetus auratus )
Mouse (Mus musculus )
Rat (Rattus norvegicus )
Mouse (Mus musculus )
Rat (Rattus norvegicus )
Mouse (Mus musculus )
Mouse (Mus musculus )
Mouse (Mus musculus )
Mouse (Mus musculus )
Rat (Rattus norvegicus )
Rat (Rattus norvegicus )
Rat (Rattus norvegicus )
Sheep (Ovis aries )
Rat (Rattus norvegicus )
Sheep (Ovis aries )
Rat (Rattus norvegicus )
Pig (Sus scrofa )

COM
LAB
COM
COM
DOM
COM
COM

Body Weight in kg

100
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40.5
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C
C
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C

Body Weight Reported?

Zinc Oxide
Zinc sulfate
Zinc methionine
Zinc acetate
Zinc oxide
Zinc sulfate heptahydrate
Zinc oxide
Zinc carbonate
Zinc carbonate
Zinc carbonate
Zinc sulfate
Zinc oxide
Zinc sulfate
Zinc oxide
Zinc sulfate
Zinc carbonate
Zinc sulfate
Zinc chloride
Zinc acetate
Zinc chloride
Zinc sulfate
Zinc carbonate
Zinc sulfate
Zinc
Zinc sulfate
Zinc sulfate
Zinc
Zinc sulfate
Zinc oxide
Zinc sulfate
Zinc chloride
Zinc sulfate heptahydrate
Zinc carbonate
Zinc carbonate
Zinc sulfate heptahydrate
Zinc oxide
Zinc sulfate heptahydrate
Zinc carbonate
Zinc oxide
Zinc sulfate
Zinc methionine
Zinc chloride
Zinc carbonate
Zinc sulfate heptahydrate
zinc acetate
Zinc carbonate
Zinc oxide
Zinc sulfate
Zinc
Zinc oxide

F
F
F
F
F
F
F

Result

Study LOAEL

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Subramanian et al, 2000
Davies, et al, 1977
Barone et al, 1998
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d
100
d GE
d
NR NR GE
d
NR NR GE
d 120-130 d GE
d
NR NR LC
d
NR NR GE
d
NR NR GE

Study NOAEL

36003
25973
25973
36854
45143
41855
43242
37008
38623
2627
39821
21084
2033
46830
42289
21067
47892
47892
21134
14660
42289
14525
14685
37015
42292
42289
21045
149
42234
42234
139
43680
40436
2203
43680
37837
43680
14656
39356
39356
39356
36374
40997
43680
638
47007
21011
14527
21042
14376

Response Site

17
10
16
18
14
22
18

Effect Measure

FD
FD
FD
FD
FD
FD
FD

Effect Type

U
U
U
U
U
U
U

General Effect Group

NR
ADL
ADL
ADL
ADL
ADL
NR

Test Location

Exposure Duration

na
na
na
na
na
na
na

Control Type

Route of Exposure

N
N
N
N
N
N
N

Sex

Method of Analyses

mg/kg diet
mg/kg diet
mg/kg bw/d
mg/kg diet
% in diet
% in diet
% in diet

Conversion to mg/kg bw/day

Lifestage

Application Frequency

0/150
0/1000
0/232
0/4000
0/0.4
0/0.4
0/0.4

Age Units

Percent Moisture

2
2
2
2
2
2
2

Age

Wet Weight Reported?

1
1
1
1
1
1
1

Duration Units

Conc/Dose Units

Rat (Rattus norvegicus )
Rat (Rattus norvegicus )
Rat (Rattus norvegicus )
Rat (Rattus norvegicus )
Rat (Rattus norvegicus )
Rat (Rattus norvegicus )
Rat (Rattus norvegicus )

Conc/ Doses

100
100
100
100
100
100
100

Test Species

Zinc sulfate
Zinc
Zinc acetate dihydrate
Zinc sulfate
Zinc
Zinc oxide
Zinc oxide

MW%

Kumar, 1976
Barone et al, 1998
Newman et al, 2002
Pal and Pal, 1987
Chu and Cox, 1972
Cox et al, 1969
Schlicker and Cox, 1968

Chemical Form

43587
21042
48540
14664
42670
42838
25

Reference

# of Conc/ Doses

Effects

Phase #

112
113
114
115
116
117
118
Growth
119
120
121
122
123
124
125
126
127
128
129
130
131
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157
158
159
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161
162
163
164
165
166
167
168

Exposure

Ref N.

Result #

Ref

6
6
6
7
7
6
7
7
6
7
6
6
6
7
10
5
7
7
10
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10
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June 2007


### Appendix 6.1 Mammalian Toxicity Data Extracted for Wildlife Toxicity Reference Value (TRV)

#### Zinc

**Page 4 of 5**

<table>
<thead>
<tr>
<th>Ref</th>
<th>Assay Code</th>
<th>Species</th>
<th>Route</th>
<th>Conc/Doses</th>
<th>Wet Weight Reported?</th>
<th>Percent Moisture</th>
<th>Duration</th>
<th>Route of Exposure</th>
<th>Effect Type</th>
<th>General Effect Group</th>
<th>Exposure Duration</th>
<th>Date</th>
<th>LOAEL Dose (mg/kg/day)</th>
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<tr>
<td>111</td>
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<td>Rat</td>
<td>Oral</td>
<td>0/0.4%</td>
<td>N</td>
<td>na</td>
<td>NR</td>
<td>FD</td>
<td>NR</td>
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<td>0.0872</td>
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<td>Rat</td>
<td>Oral</td>
<td>0/1%</td>
<td>N</td>
<td>na</td>
<td>ADL</td>
<td>U</td>
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<td>0/0.75%</td>
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<td>na</td>
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<td>NR</td>
<td>ADL</td>
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<td>NR</td>
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<td>0/0.4%</td>
<td>N</td>
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<td>NR</td>
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<td>U</td>
<td>NR</td>
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<td>N</td>
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<td>NR</td>
<td>ADL</td>
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<td>NR</td>
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<td>0.0085352</td>
<td>58</td>
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*Eco-SSL for Zinc*
### Appendix 6.1 Mammalian Toxicity Data Extracted for Wildlife Toxicity Reference Value (TRV)

#### Zinc

| Ref | Name | Species | Test Concentrations | Route of Exposure | Age | Age Units | Test Species | Route | Dose Route | Concentrations | Wet Weight Reported? | Percent Moisture | Application Frequency | Expt Duration | Study LOAEL | Body Weight Reported? | Body Weight in kg | NOAEL Dose (mg/kg/day) | LOAEL Dose (mg/kg/day) | Study Notes |
|-----|------|---------|---------------------|------------------|-----|------------|--------------|----------------|-------------|----------------|---------------------|----------------------|---------------------|----------------------|-------------|-------------|---------------------|----------------|----------------------|---------------------|------------|
| 232 | 38516 | Katouli et al., 1999 | Rattus norvegicus | 0/5400 mg/kg diet | RD | 9 w | 3-4 w | JV | B | C | COM | BIO | CHM | PCLV | BL | 5400 | Y | 181.44 | Y | 2.81232 | 83.7 | 10 | 10 | 5 | 5 | 6 | 1 | 4 | 1 | 10 | 4 | 56 |
| 233 | 14385 | Willoughby et al., 1972 | Equus caballus | 0/1000/2000 mg/kg diet | RD | 13 w | 4 w | JV | M | C | COM | BIO | CHM | PCLV | BL | 2000 | Y | 565 | Y | 22 | 77.9 | 10 | 10 | 5 | 10 | 7 | 1 | 4 | 1 | 10 | 4 | 62 |
| 234 | 14376 | Hsu et al., 1975 | Sus scrofa | 0/4000 mg/kg diet | RD | 13 w | 4 w | JV | B | C | DOM | GRO | GRO | BDWT | WO | 4000 | N | 31.5 | N | 1.17103 | 92.9 | 10 | 10 | 5 | 5 | 5 | 8 | 4 | 1 | 10 | 4 | 62 |
| 235 | 38511 | Katouli et al., 1999 | Sus scrofa | 0/5000 mg/kg diet | RD | 20 w | 5 w | JV | B | C | GRO | GRO | BDWT | WO | 5000 | Y | 140.6 | Y | 2.75 | 97.8 | 10 | 10 | 5 | 5 | 7 | 8 | 4 | 1 | 10 | 4 | 64 |
| 236 | 42838 | Cox et al., 1969 | Rattus norvegicus | 0/1200/2400/3600/4800/6000 mg/kg diet | RD | 21 d | 35 d | JV | M | C | COM | GRO | GRO | BDWT | WO | 8400 | Y | 0.1893 | Y | 0.019 | 843 | 10 | 10 | 5 | 5 | 7 | 8 | 4 | 1 | 10 | 4 | 64 |
| 237 | 14526 | Cox and Hale, 1962 | Sus scrofa | 0/0.2/0.4 % in diet | RD | 69 d | NR | NR | JV | B | C | DOM | GRO | GRO | BDWT | WO | 0.4 | Y | 59.10309 | Y | 1.98 | 134 | 10 | 10 | 5 | 5 | 7 | 1 | 4 | 1 | 10 | 4 | 57 |
| 238 | 14526 | Cox and Hale, 1962 | Sus scrofa | 0/0.2/0.4 % in diet | RD | 69 d | NR | NR | JV | B | C | DOM | GRO | GRO | BDWT | WO | 0.4 | Y | 59.10309 | Y | 1.98 | 134 | 10 | 10 | 5 | 5 | 7 | 1 | 4 | 1 | 10 | 4 | 57 |
| 239 | 14662 | Ansari et al., 1976 | Rattus norvegicus | 0/1200/2400/3600/4800/6000/7200 mg/kg diet | RD | 21 d | 35 d | JV | M | C | COM | BEH | FDB | FCNS | WO | 8400 | Y | 0.1893 | Y | 0.019 | 843 | 10 | 10 | 5 | 5 | 7 | 4 | 4 | 1 | 10 | 4 | 60 |
| 240 | 42838 | Cox et al., 1969 | Rattus norvegicus | 0/1200/2400/3600/4800/6000/7200 mg/kg diet | RD | 21 d | 35 d | JV | M | C | COM | BEH | FDB | FCNS | WO | 8400 | Y | 0.1893 | Y | 0.019 | 843 | 10 | 10 | 5 | 5 | 7 | 4 | 4 | 1 | 10 | 4 | 60 |
| 241 | 14662 | Ansari et al., 1976 | Rattus norvegicus | 0/1200/2400/3600/4800/6000/7200 mg/kg diet | RD | 21 d | 35 d | JV | M | C | COM | BEH | FDB | FCNS | WO | 8400 | Y | 0.1893 | Y | 0.019 | 843 | 10 | 10 | 5 | 5 | 7 | 4 | 4 | 1 | 10 | 4 | 60 |
| 242 | 14662 | Ansari et al., 1976 | Rattus norvegicus | 0/1200/2400/3600/4800/6000/7200 mg/kg diet | RD | 21 d | 35 d | JV | M | C | COM | BEH | FDB | FCNS | WO | 8400 | Y | 0.1893 | Y | 0.019 | 843 | 10 | 10 | 5 | 5 | 7 | 4 | 4 | 1 | 10 | 4 | 60 |
| 243 | 14662 | Ansari et al., 1976 | Rattus norvegicus | 0/1200/2400/3600/4800/6000/7200 mg/kg diet | RD | 21 d | 35 d | JV | M | C | COM | BEH | FDB | FCNS | WO | 8400 | Y | 0.1893 | Y | 0.019 | 843 | 10 | 10 | 5 | 5 | 7 | 4 | 4 | 1 | 10 | 4 | 60 |
| 244 | 43680 | Maita et al., 1981 | Rattus norvegicus | 0/0.09746 mg/g bw | DR | 7 d | NR | NR | GE | F | V | COM | BIO | CHM | MCPR | LI | 0.9746 | Y | 0.2562 | N | 0.0224289 | 975 | 10 | 8 | 10 | 4 | 10 | 1 | 4 | 1 | 10 | 4 | 62 |
| 245 | 43680 | Maita et al., 1981 | Rattus norvegicus | 0/24.5/243/2486 mg/kg bw/d | RD | 13 w | 5 w | JV | F | C | COM | BEH | FDB | FCNS | WO | 2486 | Y | 0.231 | Y | 0.0149 | 2486 | 10 | 10 | 5 | 10 | 7 | 4 | 4 | 1 | 10 | 4 | 65 |
| 246 | 43680 | Maita et al., 1981 | Rattus norvegicus | 0/46.4/479/4878 mg/kg bw/d | RD | 13 w | 5 w | JV | F | C | COM | BEH | FDB | FCNS | WO | 4878 | Y | 0.0327 | Y | 0.0036 | 4878 | 10 | 10 | 5 | 10 | 7 | 4 | 4 | 1 | 10 | 4 | 65 |
| 247 | 43680 | Maita et al., 1981 | Rattus norvegicus | 0/42.7/458/4927 mg/kg bw/d | RD | 13 w | 5 w | JV | M | C | COM | BEH | FDB | FCNS | WO | 4927 | Y | 0.0386 | Y | 0.0054 | 4927 | 10 | 10 | 5 | 10 | 7 | 4 | 4 | 1 | 10 | 4 | 65 |
| 248 | 21006 | Sinha, et al., 1989 | Rattus norvegicus | 0/200 mg/L | RD | 18 mo | NR | NR | JV | F | C | COM | PHY | PHY | BLPR | WO | 200 | N | 0.179 | N | 0.0210476 | 23.5 | 10 | 5 | 5 | 5 | 4 | 4 | 1 | 10 | 4 | 62 |
| 249 | 45042 | Katya-Katya et al., 1984 | Rattus norvegicus | 0/200 mg/L | RD | 18 mo | NR | NR | JV | F | C | COM | PHY | PHY | BLPR | WO | 200 | N | 0.179 | N | 0.0210476 | 23.5 | 10 | 5 | 5 | 5 | 4 | 4 | 1 | 10 | 4 | 62 |

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