AVIAN TOXICITY REFERENCE VALUES (TRVs) FOR PERFLUOROOCTANE SULFONATE (PFOS)

John L. Newsted1, John P. Giesy2, Paul D. Jones3

1ENTRIX, Inc., Okemos, MI 48864, 2Zoology Department, National Food Safety and Toxicology Center, Center for Integrative Toxicology, Michigan State University, East Lansing MI 48824

Toxicity Reference Values (TRVs) and Predicted No Effect Concentrations (PNECs) were derived for perfluorooctane sulfonate (PFOS) based on the characteristics of a top avian predator. The benchmarks are protective of avian populations and were based on acute and chronic dietary exposures of northern bobwhite quail and mallards. Toxicological endpoints included mortality, growth, feed consumption, and histopathology. Reproductive endpoints included egg production, fertility, hatchability and survival and growth of offspring. Based on USEPA Great Lakes Initiative (GLI) methodology, an uncertainty factor of 36 was derived. The TRV based on PFOS dietary intake was 0.021 mg PFOS/kg dw/week for sensitive species, and 0.18 mg PFOS/kg dw/week, respectively.

INTRODUCTION

• Perfluorooctane sulfonate (PFOS) is a fluoro-saturated, eight-carbon acid with a terminal sulfonate that has been found to be resistant to hydrolysis, photolysis, microbial degradation, and metabolism by animals.

• PFOS has amphipathic and unique molecular properties such that it exhibits both water and oil repellency when absorbed on textile and paper.

• In global monitoring studies, PFOS has been documented in wildlife populations, including bird populations from both urban and remote locations.

• To date, the toxicological and ecological significance of avian PFOS concentrations has not been fully evaluated.

OBJECTIVES

• Characterize chronic effects of PFOS in two avian species, mallards and bobwhite quail.

• Determine No Observed Effect Levels (NOEL) and Lowest Observed Effect Levels (LOEL) in avian species.

• Test Toxicity Values (TRVs) based on dietary and tissue PFOS concentrations.

• Compare TRVs to literature values.

TEST SPECIES

Mallard (Anas platyrhynchos)

• Order Anseriformes, Family Anatidae

• Surface feeding dabbling duck (waterfowl)

• Feed primarily on aquatic plants and aquatic insects

Northern Bobwhite (Colinus virginianus).

• Order Galliformes, Family Odontophoridae

• Ground-dwelling, upland game bird. Feeds primarily on weeds, woody plants and grasses. Adults also consume insects and other invertebrates

ACUTE DIETARY STUDIES

Method: OPPTS 850.2200 (Dabai), FIFRA Subdivision E, Section 71-2, OECD 205

Test Phases:

(1) Acclimation for 10 days; (2) Exposure for 5 days; (3) Post-exposure and recovery for 3 or 17 days.

Juvenile Age: 10 days old at test initiation

Experimental Design:

• Nominal Doses: 0 (control), 8, 17, 36, 50, 100, 150, 200, 250, and 125 ppm

• Replicates: Six replicates in the control and two replicates per treatment. Five quail per replicate

Sample Collection:

Three replicates in the control and one replicate per treatment sampled on Day 8. Remaining birds sampled on Day 22

RESULTS

• Dietary PFOS exposure resulted in dose dependent mortality.

• Signs of toxicity observed in birds prior to death included reduced activity, ruffled appearance, reduced growth, ruffled appearance, and loss of coordination.

• At the highest treatments, signs also included loss of body weight, growth, feed consumption, and reduced response to stimuli.

• When compared to controls, there was a decrease in the intensity of stress tests in males treated with PFOS in the diet. In some males with small testes, spermatogenesis was decreased as characterized by a reduction in the number of spermatid-mature spermatozoa in the seminiferous tubules. Results were suggestive of a PFOS related acceleration of post-reproductive regression, a normal physiological process.

Reproduction:

• No treatment-related effects noted on any reproductive parameters including measures of egg production, fertility, viability, and hatchability.

• No effects noted on chick survivability or on body and liver weights.

TOXICITY REFERENCES

TRV = Test Dose or LOAEL

T0 = Overall UF for TRV

Male Female

PFOS (mg/kg WW) TRV TRV

1.5 1.73 0.57 0.46

10 0.77 0.65

50 0.38 0.29

150 0.19 0.15

200 0.14 0.11

250 0.11 0.09

562 ppm 0.01 0.00

1125 ppm 0.00 0.00

Comparison of avian TRVs to tissue PFOS concentrations taken from the literature as part of global monitoring studies.

• Blood, serum and plasma were treated as equivalent matrices. Whole blood PFOS values were divided by 2 to create plasma equivalents.

• Whole egg yolk and yolk data compared to yolk-based TRV.

• Overall, 90% or greater of all samples had hazard quotients (HQ) of less than 1.0 and no HQ exceeded 3 for any species or tissue. No tissue concentrations of PFOS and LOAELs values from the quail study.

• For plasma concentrations, 6 out of 62 samples had HQ values greater than 1.0. HQs ranged from 0.001 to 2.6 with a median value of 0.17.

• For liver concentrations, 12 out of 220 samples had HQ values greater than 1.0. HQs ranged from 0.002 to 2.9 with a median value of 0.11.

• For egg concentrations, 6 out of 60 samples had HQ values greater than 1.0. HQs for egg PFOS concentrations ranged from 0.004 to 1.9 with a median 0.09.

• Due to the conservative nature of the TRVs, exceedances would not necessarily result in population-level effects. Rather, it indicates that there may be a possibility for adverse effects but additional site specific information is required.

• Based on the Great Lakes Initiative (GLI) findings and best professional judgment, these are given (Table 3).

• Toxicological studies with PFOS. a

• No effects noted on chick survivability or on body and liver weights.

MORTALITY RESULTS

Nonlethal Endpoints (10 mg PFOS/kg treatment only)

• No treatment-related effects noted on body weight, body weight gain, liver weight, or feed consumption in adult mallards

• No treatment-related lesions noted in adult females

• When compared to controls, there was a decrease in the intensity of stress tests in males treated with PFOS in the diet. In some males with small testes, spermatogenesis was decreased as characterized by a reduction in the number of spermatid-mature spermatozoa in the seminiferous tubules. Results were suggestive of a PFOS related acceleration of post-reproductive regression, a normal physiological process.

Reproduction:

• No treatment-related effects noted on any reproductive parameters including measures of egg production, fertility, viability, and hatchability.

• No effects noted on chick survivability or on body and liver weights.

Table 2. NOAEL and LOAEL values from reproductive studies conducted with mallards and bobwhite quail exposed to PFOS in dietary, liver, and remote locations. a

<table>
<thead>
<tr>
<th>Test Species</th>
<th>Test Site</th>
<th>Treatment</th>
<th>Exposure Route</th>
<th>NOAEL</th>
<th>LOAEL</th>
</tr>
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<tbody>
<tr>
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<td>0.1 mg/kg</td>
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<tr>
<td></td>
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MALLARD RESULTS

Nonlethal Endpoints (10 mg PFOS/kg treatment only)

• Clinical signs including reduced reaction to stimuli, ruffled appearance, lethargy noted in adult quail at week 5

• Nonlethal endpoints noted in adult females

• When compared to controls, there was a decrease in the intensity of stress tests in males treated with PFOS in the diet. In some males with small testes, spermatogenesis was decreased as characterized by a reduction in the number of spermatid-mature spermatozoa in the seminiferous tubules. Results were suggestive of a PFOS related acceleration of post-reproductive regression, a normal physiological process.

Reproduction:

• No treatment-related effects noted on egg production.

• Slight reductions in fertility, hatchability and offspring survival including number of viable embryos as percentage of egg set, hatchlings as a percentage of live 3-week old embryos.

• Statistically significant reduction in the number of 14-day old survivors as a percentage set.

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SCREENING LEVEL ASSESSMENT

• For egg concentrations, 6 out of 62 samples had HQ values greater than 1.0. HQs ranged from 0.001 to 2.6 with a median value of 0.17.

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