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Inorganic Element Concentrations in Passerine Eggs Collected at Technical Areas 36, 39, and 16 at Los Alamos National Laboratory

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ACRONYMS AND TERMS

| | |
|--------|---|
| ALS | Australian Laboratory Services |
| EPA | Environmental Protection Agency |
| LOAELs | lowest observable adverse effect levels |
| mg/kg | milligrams per kilogram |
| RSRLs | regional statistical reference levels |
| TA | Technical Area |
| TAL | total analyte list |

SUMMARY

In 2018, nonviable avian eggs were opportunistically collected at Los Alamos National Laboratory near open detonation sites at Technical Area (TA) 36 and TA-39 and near the TA-16 burning grounds and were evaluated for inorganic elements (mostly metals). A total of eight western bluebird (*Sialia mexicana*) and ash-throated flycatcher (*Myiarchus cinerascens*) egg samples were collected among the three locations of interest. Due to the small sample size, statistical comparisons could not be made. However, concentrations of inorganic elements observed in this study were compared with the upper-level bounds of background concentrations (mean + three standard deviations = 99% confidence interval; regional statistical reference level [RSRL]). Several inorganic elements were not detected in avian eggs and the majority of inorganic elements detected were below the RSRL. The few elements that exceeded the RSRL were below the lowest observable adverse effect level (LOAEL), when available. These data suggest that inorganic element concentrations in eggs observed here are not of ecological concern. As these data are preliminary, more data are needed to make a robust assessment, including additional background samples.

INTRODUCTION

Biomonitoring is an important tool for assessing environmental contamination by analyzing chemicals or their metabolites from biological tissues (Becker 2003). Avian eggs and nestlings are useful as bioindicators because different species occupy many trophic levels. Additionally, the collection of nonviable eggs and/or nestlings that die of natural causes is noninvasive and is nondestructive to populations. Inorganic elements and organic chemicals can pose risks of adverse effects to birds if exposed at high enough concentrations (Jones and de Voogt 1999). Levels of some constituents in biological tissues can also indicate whether adverse effects could be expected (Gochfeld and Burger 1998). Examining population parameters along with tissue concentrations provides a more comprehensive and robust assessment of potential impacts caused by environmental pollution.

Sources of inorganic elements include both anthropogenic and natural sources and birds can be exposed through a number of routes including diet, ingestion of soil, drinking water, and inhalation. Inorganic elements (mostly metals) and dioxins and furans are of interest at open-detonation firing sites (TA-36 and TA-39) and at the burn grounds at TA-16 (Fresquez 2011).

OBJECTIVES

The objective of this study is to document chemical concentrations in eggs and nestlings collected near TAs 36, 39, and 16 and to compare concentrations of inorganic elements observed in this study with the upper-level bounds of background concentrations.

METHODS

Sample Collection

Eggs were collected from nest boxes when they were determined to be nonviable due to documented timing of known incubation periods for the species. In 2018, two nonviable egg samples were collected from TA-36, two egg samples from TA-39, and four samples from TA-16. All egg samples were either western bluebirds (*Sialia mexicana*) or ash-throated flycatchers (*Myiarchus cinerascens*) and were collected in June and July of 2018. No nestling samples were obtained in 2018 because the nest boxes located in the areas of interest did not have nestlings that died of natural causes that could be collected opportunistically.

Chemical Analyses

Due to limited sample mass, nonviable eggs were analyzed for TAL only and were analyzed at ALS (Australian Laboratory Services, formerly Paragon Analytics, Inc.) in Fort Collins, Colorado. The two samples collected near TA-36 and submitted for analyses consisted of one individual western bluebird egg and one composite of six western bluebird eggs. The two samples collected near TA-39 and submitted for analyses consisted of one individual ash-throated flycatcher egg and one composite of three western bluebird eggs. The four samples collected near TA-16 and submitted for analyses consisted of two individual western bluebird eggs, one composite of four western bluebird eggs, and one composite of two ash-throated flycatcher eggs.

Antimony, arsenic, cadmium, lead, selenium, silver, and thallium concentrations were measured by inductively coupled plasma mass spectrometry (Environmental Protection Agency [EPA] SW-846 Method 6020A), and aluminum, barium, beryllium, calcium, chromium, cobalt, copper, iron, magnesium, manganese, nickel, potassium, sodium, vanadium, and zinc were measured by inductively coupled plasma atomic emission spectrometry (EPA SW-846 Method 6010B). Mercury was measured by cold-vapor atomic absorption procedure (EPA SW-846 Method 7471A). All metal results were reported on an mg/kg (milligram per kilogram) dry weight basis.

Analyses of Chemical Levels

The 2018 results could not be statistically compared with background data due to small sample sizes; more data are needed to enable a robust evaluation of open detonation sites and background locations. However, results from 2018 were compared with the regional statistical reference levels (RSRL), which represents natural and fallout levels of chemicals, and are the upper-level bounds of background concentrations (mean + three standard deviations = 99% confidence interval). Regional statistical reference levels were calculated from nonviable eggs of western bluebirds and ash-throated flycatchers at background locations from Bandelier National Monument in 2016 and 2018 (n=8). Results were also compared with the lowest observable adverse effect levels (LOAEL) from peer reviewed literature, when available.

PRELIMINARY RESULTS AND DISCUSSION

Many of the inorganic elements assessed in this study were not detected in passerine egg samples. Elements that are not (or very little is) maternally transferred into eggs or do not accumulate in eggs include cadmium (Leach et al. 1979; Stoewsand et al. 1986), lead (Pattee 1984), vanadium (White and Dieter 1978), and silver (Schwarzbach et al. 2006; Seiler and Skorupa 2001).

Minie Firing Site (TA-36)

The two western bluebird egg samples collected from TA-36 did not have detectable levels of several elements including aluminum, antimony, arsenic, beryllium, cadmium, lead, nickel, silver, or vanadium. Detectable concentrations of barium, calcium, chromium, cobalt, iron, magnesium, manganese, mercury, potassium, selenium, sodium, thallium, and zinc were all below the RSRL and the LOAEL (when available). One egg sample contained copper concentrations of 4.1 mg/kg that was higher than the RSRL of 3.6 mg/kg (Table 1).

The elevated copper in western bluebird egg samples observed in 2018 at TA-36 and TA-39 (see below) are similar with previous observations (Gaukler, 2017) and could be from some high-explosives testing. Copper has historically been detected above soil screening levels at Technical Area 39 (Juarez and Vigil-holterman 2011). Contrarily, copper soil levels at Technical Area 36, near the firing site were below the RSRL in 2018. No reliable screening levels exists for egg tissues, although it has been suggested that birds are relatively resistant to copper toxicity when compared with other taxa (Eisler 1998).

TA-39

Two egg samples collected from nest boxes at TA-39 did not contain detectable concentrations of aluminum, antimony, arsenic, beryllium, cadmium, chromium, lead, nickel, silver, thallium, or vanadium. Detectable concentrations of barium, cobalt, and zinc were all below the RSRL. One western bluebird egg sample contained higher concentrations of calcium, copper, iron, magnesium, manganese, mercury, potassium, selenium, and sodium compared with RSRLs (Table 2). Although calcium, magnesium, potassium, and sodium were higher in eggs collected at Technical Area 39 compared with the RSRL, these elements are macronutrients, which are required by living organisms in large quantities. Copper, iron, manganese and selenium are essential micronutrients to living organisms in small concentrations, but can become toxic at high enough levels. No reliable screening levels are available for copper, iron, and manganese; however, both mercury and selenium egg concentrations were below the LOAELs for these elements (Heinz et al 1996; Thompson et al 1996)

TA-16 Burn Grounds

Western bluebird and ash-throated flycatcher eggs collected from nest boxes at TA-16 did not contain detectable concentrations of aluminum, arsenic, beryllium, cadmium, lead, nickel, thallium or vanadium. One sample out of the four collected contained higher concentrations of antimony (0.21 mg/kg) compared with the RSRL (0.11 mg/kg). Two samples out of four collected contained higher concentrations of mercury (0.23 and 0.25 mg/kg) compared with RSRLs (0.18 mg/kg; Table 3). However, both of the samples were below the LOAEL for mercury (1.67 mg/kg, converted from wet to dry weight), suggesting that adverse health effects are not expected at the observed concentrations (Thompson et al 1996). No reliable screening levels are available for antimony; therefore, it is unknown at what concentrations adverse effects could be expected.

CONCLUSIONS

The overall results indicate that the levels of inorganic elements in the eggs of western bluebirds and ash-throated flycatcher are not likely to cause adverse effects in breeding bird populations. Most constituents were not detected in the nonviable egg samples collected near firing sites at TA-36 and TA-39 and the burning grounds at TA-16. Most constituents that were detected were below RSRLs and all were below the LOAELs (when available). These data suggest that egg elements concentrations observed here are not of ecological concern. As these data are preliminary, more data from nonviable eggs and nestlings are needed to make a robust assessment, including additional

background samples. Evaluating avian nestling samples for high explosives is also of interest for future work as those data become available.

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Table 1. Inorganic element concentrations (mg/kg dry weight) detected in eggs collected near the Minie Firing Site (TA-36) compared with RSRL. The RSRL is the upper limit background concentrations (mean + three standard deviations) for passerine eggs based on data from 2016-2018 (n=8).

| Element | Western bluebird | Western bluebird | RSRL |
|-----------|------------------------|------------------------|--------|
| | (n=1) SFB-18-160523 | (n=6) SFB-18-160524 | |
| Barium | 19 | 12 | 35 |
| Calcium | 3100 | 3200 | 4983 |
| Chromium | ND | 0.22 | 1.3 |
| Cobalt | ND | 0.03 | 0.6 |
| Copper | 2.8 | 4.1 | 3.6 |
| Iron | 160 | 130 | 250 |
| Magnesium | 390 | 350 | 447 |
| Manganese | 1.6 | 2.9 | 4.5 |
| Mercury | 0.04 | 0.08 | 0.18 |
| Potassium | 7500 | 7500 | 12040 |
| Selenium | 1.9 | 2.1 | 3.2 |
| Sodium | 7300 | 7600 | 10299 |
| Thallium | ND | 0.0019 | 0.0192 |
| Zinc | 46 | 51 | 78 |

ND = nondetect

Bold values indicate a detectable concentration that is higher than the RSRL.

Table 2. Inorganic element concentrations (mg/kg dry weight) detected in eggs collected near TA-39 compared with RSRL. The RSRL is the upper limit background concentrations (mean + three standard deviations) for passerine eggs based on data from 2016-2018 (n=8).

| Element | Western bluebird | Ash-throated | RSRL |
|-----------|------------------------|--------------------------------------|-------|
| | (n=3) SFB-18-160525 | flycatcher (n=1) SFB-18-160526 | |
| Barium | 11 | 7.9 | 35 |
| Calcium | 8900 | 2400 | 4983 |
| Cobalt | 0.15 | 0.06 | 0.6 |
| Copper | 9.2 | 2.4 | 3.6 |
| Iron | 350 | 86 | 250 |
| Magnesium | 1100 | 330 | 447 |
| Manganese | 6.5 | 0.78 | 4.5 |
| Mercury | 0.62 | 0.15 | 0.18 |
| Potassium | 27000 | 7600 | 12040 |
| Selenium | 8.3 | 2.6 | 3.2 |
| Sodium | 24000 | 9200 | 10299 |
| Zinc | 150 | 33 | 78 |

ND = nondetect

Bold values indicate a detectable concentration that is higher than the RSRL.

Table 3. Inorganic element concentrations (mg/kg dry weight) detected in eggs collected near TA-16 burning grounds compared with RSRL. The RSRL is the upper limit background concentrations (mean + three standard deviations) for passerine eggs based on data from 2016-2018 (n=8).

| Element | Western bluebird | Ash-throated | Western bluebird | Western bluebird | RSRL |
|-----------|------------------|---------------|------------------|------------------|-------|
| | (n=1) | flycatcher | (n=1) | (n=4) | |
| | SFB-18-160510 | SFB-18-160520 | SFB-18-160521 | SFB-18-160522 | |
| Antimony | 0.21 | ND | ND | ND | 0.11 |
| Barium | 15 | 6.8 | 12 | 9.8 | 35 |
| Calcium | 600 | 3700 | 2900 | 2900 | 4983 |
| Chromium | ND | ND | ND | 0.28 | 1.3 |
| Cobalt | ND | 0.07 | ND | 0.04 | 0.6 |
| Copper | 3.2 | 3.1 | 2.2 | 2.5 | 3.6 |
| Iron | 38 | 150 | 87 | 190 | 250 |
| Magnesium | 420 | 320 | 290 | 320 | 447 |
| Manganese | 1.3 | 2.3 | 1.8 | 3.1 | 4.5 |
| Mercury | 0.23 | 0.25 | 0.16 | 0.13 | 0.18 |
| Potassium | 11000 | 8200 | 8400 | 8200 | 12040 |
| Selenium | 1.3 | 3.2 | 2.9 | 2.7 | 3.2 |
| Silver | ND | 0.026 | ND | ND | 0.04 |
| Sodium | 8700 | 7600 | 9100 | 6700 | 10299 |
| Zinc | 8.7 | 50 | 30 | 54 | 78 |

ND = nondetect

Bold values indicate a detectable concentration that is higher than the RSRL.