Effect of Six Chemical Deicers on Survival and Activity of Larval Wood Frogs (*Lithobates sylvatica*)

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Introduction

Road salts and chemical deicers are heavily applied in cold climates of North America and have detrimental impacts on freshwater ecosystems. Numerous alternatives such as inorganic salts, glycols, acetates, formates, and urea, are being used with increased frequency. Amphibians, particularly when in larval form, are extremely sensitive to such environmental contaminants due to a highly permeable skin (Duellman and Trueb 1986). Previous studies have documented negative effects of chemical deicers on amphibians (Turtle 2000; Sanzo and Hecnar 2006; Karraker 2007). All deicers are not equal, and this demands toxicological studies with non-model organisms to assess their environmental impact. In this study we investigated the effect of road salt and alternatives on the survivorship of larval wood frogs (*Lithobates sylvatica*).

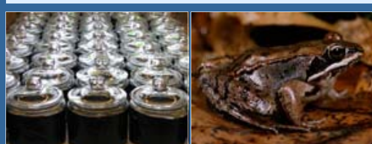

Figure 1. Experimental chambers used in the 96 hour acute toxicity test (left) and an adult *Lithobates sylvatica* (right).

Methods

We performed a series of acute toxicity tests with six chemical deicers using larval wood frogs (*Lithobates sylvatica;* Figure 1). We collected recently deposited egg masses from Baraga County, MI and maintained them in 20L aquaria. Tadpoles that absorbed their gills and attained Gosner stage 25 were used for all six toxicity trials (Gosner 1960). For each trial, we exposed tadpoles to one of 11 concentrations of each of six chemical deicers for 96h with four replicates per treatment. We set up 3L glass jars filled with 2L of filtered water from Portage Lake, MI and 10 pre-sorted tadpoles of similar size as experimental chambers. Every 24 hours, we counted the number of surviving tadpoles and recorded the number of tadpoles swimming in each jar. At the end of each trial, we fixed all tadpoles in a 10% formalin solution. We calculated trimmed Spearman-Karber estimates of LC_{50} (lethal median concentration) for each trial.

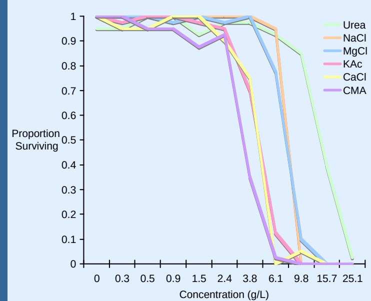

Figure 2. Mean proportion of surviving tadpoles at the end of 96-hours varied slightly with each deicer type. Trends in the decrease in tadpole survivorship follow LC_{50} values where deicers with low LC_{50} values experienced the highest mortality at low concentrations.

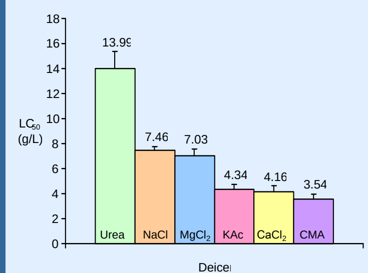

Figure 3. *Lithobates sylvatica* tadpoles were most sensitive to calcium magnesium acetate (CMA), calcium chloride ($CaCl_2$), and potassium acetate (KAc) contamination. Tadpoles tolerated short term exposure to magnesium and sodium chlorides ($MgCl_2$, NaCl) to a higher degree, with the highest tolerance for urea (NH_3).

Results

- Highest tadpole mortality occurred at upper concentrations of each deicer, with a mean proportion of tadpole mortality per jar ranging from 0.3 - 36.5 (Figure 2).
- LC_{50} values for each deicer varied greatly by type (range 3.54 - 13.99), with tadpoles most sensitive to calcium magnesium acetate (CMA; Figure 3).
- LC_{50} values were not significantly different among the deicers ($F_{1,51}$ = 0.61, $p > 0.05$).

Discussion

The LC_{50} values for tadpoles exposed to NaCl calculated in this study are much higher than previous studies on *Lithobates sylvatica* and *L. clamitans* (2.63 g/L, Sanzo and Hecnar 2006; .406 g/L, Dougherty and Smith 2006). This suggests that this population may be less sensitive to road salt contamination than other populations. Acetates (KAc and CMA) appear to have a greater impact on tadpole survivorship than chloride compounds (Figures 2, 3). *L. sylvatica* tadpoles were most sensitive to popular, "environmentally friendly" road salt alternatives, namely CMA that does not contain harmful chloride.

Discussion (cont.)

Proportion of tadpole survival at the end of the 96 hour acute test varied slightly by deicer type (Figure 2). Survival decreased as concentration increased with few tadpoles surviving at 15.7 and 25.1 g/L concentrations. Trends in the proportion surviving loosely follow patterns in the LC_{50} values, where deicers with lower LC_{50} values had the lowest survival at 96 hours.

Though road salt itself is detrimental to survival and health of *L. sylvatica* tadpoles, results suggest that popular alternatives may be more harmful. Further, long-term research on the impacts of these alternatives is warranted. Understanding the impact of these chemicals on sensitive species such as amphibians may help to promote holistic conservation measures for freshwater ecosystems. We are presently conducting research on the chronic effects of road salt pollution on both *L. sylvatica* and *L. clamitams*. This addition to the study will help to shed light on the long term effects of this stressor on amphibian communities.

Figure 4. Six chemicals commonly used for chemical deicing and anti-icing procedures in North America.

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