ABSTRACT

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Title: Road-Salt Induced Developmental Malformations in Wood Frogs Resolve During Early Larval Development

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Road salt application has increased dramatically over the past half century, resulting in the salinization of freshwaters across the globe. Among the many freshwater taxa that have been impacted by this form of pollution, amphibians have received considerable attention, perhaps because of their permeable skin and because many amphibians generally have limited capacity for coping with strong osmotic gradients. Moreover, amphibians often breed in small, shallow habitats which can become heavily salinized when situated near a road. Numerous studies have reported negative effects of both roadside dwelling and direct experimental salt exposure on many species of amphibians. Consequences include decreased developmental rates, increased stress and edema, increased risk of disease, decreased survival, and ultimately reduced population fitness. Yet roads and road salt can also spur evolutionary change, causing local populations to diverge in their tolerance for salt pollution. Some species show evidence for local adaptation to roads and road salt pollution. However, one species shows evidence for local maladaptation, with traits in 'roadside' populations being less fit to roadside conditions than traits found in neighboring 'woodland' populations. Specifically, roadside populations of the wood frog (Rana sylvatica) show a developmental and survival disadvantage relative to woodland populations when exposed to salt, with embryonic stages being most sensitive to salt. Here, we asked whether mortality is stage specific across embryonic development and whether developmental malformations might explain increased mortality of roadside wood frog embryos exposed to salt. We used a common garden exposure experiment to track survival, development, and malformation in 216 wood frog embryos exposed to either control or elevated road salt conditions. In contrast to prior studies, we found no effect of population type or salt on survival. However, salt had a strong effect on malformations. 100% of all salt-treated individuals showed a developmental malformation while no malformations were found in the control treatment. Interestingly, almost all malformations resolved by the time embryos developed into feeding-stage larvae. This pattern suggests that salt-induced developmental malformations in wood frog embryos are fleeting and do not contribute to mortality.