

# ECOTOXICOLOGICAL RISKS OF GLYPHOSATE TO FROGS – A CASE STUDY IN COLOMBIA

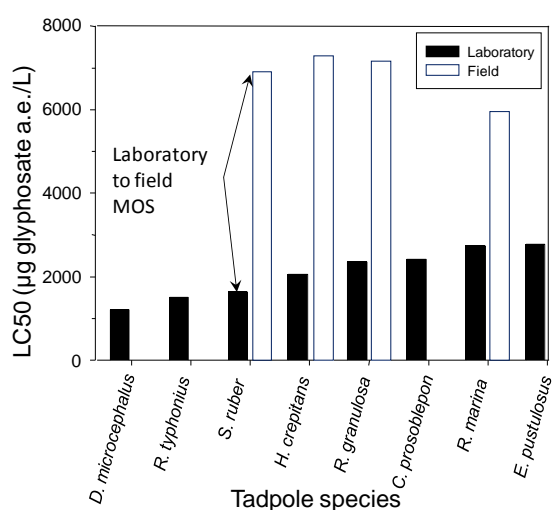
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The herbicide, glyphosate, is used in the effort to control the supply of cocaine produced from the coca plant (*Erythroxylum coca* and *E. novogranatense*). Formulated glyphosate (not the technical a.i.) have been reported to be toxic to aquatic [1-5] and terrestrial stages [6] of amphibians, suggesting that glyphosate formulations, such as used in control of coca may present a risk to amphibians in Colombia [7]. To address this issue and to provide additional toxicity data for tropical species of frogs, a series of studies were conducted on tadpoles under laboratory conditions [8] and on tadpoles in the field, as well as on terrestrial stages of frogs [9].

Gosner stage-25 tadpoles of *Scinax ruber*, *Dendrosophus microcephalus*, *Hypsiboas crepitans*, *Rhinella granulosa*, *Rhinella marina*, *Rhinella typhonius*, *Centrolene prosoblepon*, and *Engystomops pustulosus* were exposed for 96 h to the solutions of formulated glyphosate as used in control of coca (coca mixture) at concentrations from 1 to 4.2 mg a.e./L. Test solutions were renewed every 24 h and the concentration of glyphosate measured at the beginning and end of the exposure period. To characterize toxicity under field conditions, Gosner stage 25 tadpoles of *Rhinella granulosa*, *R. marina*, *Hypsiboas crepitans* and *Scinax ruber* were placed in outdoor microcosms containing a 3 cm layer of local soil overlaid with 15 cm of local spring water and sprayed with the coca mixture at concentrations greater and less than the normal application rate (3.69 kg glyphosate a.e./ha). Terrestrial stages of frogs were exposed by direct spraying to a range of concentrations of coca mixture in plastic food containers (19 x 19 cm), the bottom of which was filled with moistened soil and leaf litter to a depth of 1 cm and 0.5 cm, respectively. Mortality was observed at 96 h.

In the laboratory, LC50 values for tadpoles ranged from 1,200 to 2,780 µg glyphosate a.e./L for the 8 species tested. Data suggest that sensitivity to Roundup®-type formulations of glyphosate in these species is similar to that observed in other tropical and temperate species. However, when exposed in the field microcosms in the presence of sediments, LC50 values were between 8.9 and 10.9 kg glyphosate a.e./ha (equivalent to initial concentrations of 5,963 to 7,303 µg glyphosate a.e./L). Mortality >LC50 was only observed in the tested species when the application rate was > 2-fold the normal application rate of 3.7 kg glyphosate a.e./ha. Reduced sensitivity in the field (Figure) was probably because of reduced bioavailability due to adsorption to sediments and particulates in the water. Thus,



**Figure. Sensitivity of tadpole species to the spray mixture in the laboratory and field.**

[Adapted from 9].

risks to larval frogs (representing sensitive aquatic organisms) from the coca mix as well as other uses would be reduced by adsorption to sediments under field conditions and, even with direct overspray, amphibians in shallow water systems would be at low risk.

For the terrestrial stages of the frogs LC50 values ranged between 4.5 kg a.e./ha and 22.8 kg a.e./ha, 1.5- to 6-fold greater than the normal application rate. The results of these tests showed a range of responses but not the high sensitivity that had been stated in some reports in the literature [6] and are consistent with recent reports of toxicity to terrestrial stages of toads [10]. The overall conclusions of the toxicity studies on Colombian frogs are that, under worst-case exposure conditions, glyphosate as used for control of coca in Colombia is of low or negligible risk to aquatic and juvenile terrestrial stages of frogs. As agricultural rates of application are usually lower, risks from these uses are even smaller.

- [1] Mann RM, Bidwell JR. 1999. The toxicity of glyphosate and several glyphosate formulations to four species of Southwestern Australian frogs. *Arch Environ Contam Toxicol* 36:193-199.
- [2] Edginton AN, Sheridan PM, Stephenson GR, Thompson DG, Boermans HJ. 2004. Comparative effects of pH and Vision herbicide on two life stages of four anuran amphibian species. *Environ Toxicol Chem* 23:815-822.
- [3] Howe CM, Berrill M, Pauli BD, Helbing CC, Werry K, Veldhoen N. 2004. Toxicity of glyphosate-based pesticides to four North American frog species. *Environ Toxicol Chem* 23:1928-1938.
- [4] Cauble K, Wagner RS. 2005. Sublethal effects of the herbicide glyphosate on amphibian metamorphosis and development. *Bull Environ Contam Toxicol* 75:429-435.
- [5] Relyea RA. 2005. The lethal impacts of Roundup and predatory stress on six species of North American tadpoles. *Arch Environ Contam Toxicol* 48:351-357.
- [6] Relyea RA. 2005. The lethal impact of Roundup on aquatic and terrestrial amphibians. *Ecol Appl* 15:1118-1124.
- [7] Solomon KR, Anadón A, Carrasquilla G, Cerdeira A, Marshall J, Sanin L-H. 2007. Coca and poppy eradication in Colombia: Environmental and human health assessment of aerially applied glyphosate. *Rev Environ Contam Toxicol* 190:43-125.
- [8] Bernal MH, Solomon KR, Carrasquilla G. 2009. Toxicity of formulated glyphosate (Glyphos®) and Cosmo-Flux® to larval Colombian frogs 1. Laboratory acute toxicity. *J Toxicol Environ Hlth* 72:In Press.
- [9] Bernal MH, Solomon KR, Carrasquilla G. 2009. Toxicity of formulated glyphosate (Glyphos®) and Cosmo-Flux® to larval and juvenile Colombian frogs 2. Field and laboratory microcosm acute toxicity. *J Toxicol Environ Hlth* 72:In Press.
- [10] Dinehart SK, Smith LM, McMurry ST, Anderson TA, Smith PN, Haukos DA. 2009. Toxicity of a glufosinate- and several glyphosate-based herbicides to juvenile amphibians from the Southern High Plains, USA. *Sci Tot Environ* 407:1065-1071.