The Cocktail Effect

Pesticides Prove Deadlier in Combination

Australian fish hatchery owner Gwen Gilson was startled when two-headed fish started appearing in a recent crop of hatchlings. Many of Gilson's hatchlings died while others struggled to survive with horrible deformities and strange behavioral disorders. An investigation by Queensland's Biosecurity Sciences Laboratory suggested the problem was caused by "a cocktail of chemicals" sprayed over a nearby macadamia plantation.

A New South Wales government study found residues of as many as six pesticides on individual vegetable crops in the territory. Tree plantation owners often kill weeds with atrazine and simazine, chemicals that disrupt human hormones and can trigger cancer. "When two or more such chemicals are combined," *The Australian* newspaper warns, "they may pack a mightier punch than each would individually." A study in *Environmental Health Perspectives* recently confirmed this "cocktail effect." When U.S. researchers exposed young fish to combinations of organophosphates and carbamates at "sub-lethal" concentrations, the mix proved even deadlier.

Research by the National Oceanic and Atmospheric Administration (NOAA) Fisheries Service and Washington State University found that combinations of common agricultural pesticides are deadlier to salmon than previously believed. The researchers examined diazinon, malathion, chlorpyrifos, carbaryl and carbofuran—all known to damage the nervous system—and reported that certain pesticides acted synergistically, producing mixtures that were more harmful than the sum of the individual chemicals. The study, published in *Environmental Health Perspectives,* concluded that the current practice of testing individual pesticides fails to show actual toxicity risks. In 2008, NOAA Fisheries reported that diazinon, malathion and chlorpyrifos threatened the survival of all 28 species of Pacific salmon. NOAA research zoologist Nathaniel Scholz has suggested: "We need to design new research that takes into effect the real-world situation where pesticides almost always coincide with other pesticides."

When mixed together at concentrations officially considered "safe," ten of the world's most widely used pesticides can combine to produce a chemical cocktail that is deadlier than any of the chemicals acting alone. University of Pittsburgh Associate Professor of Biological Sciences Rick Relyea reported this finding in the journal *Oecologia* after combining small amounts of five insecticides (carbaryl, chlopyrifos, diazinon, endosulfan, malathion) and five herbicides (acetochlor, atrazine, glyphosate, metolachlor and 2,4-D). Relyea found a mixture of all 10 chemicals (at concentrations below the maximum concentrations found in ponds and lakes) killed 99% of Leopard frog tadpoles. Relyea also found that endosulfan "appears to be about 1,000-times more lethal to amphibians than other pesticides. Unfortunately, [EPA] pesticide regulations do not require amphibian testing."

Toxicologists generally use short-term tests to examine potential impacts of pesticides on non-target organisms but this approach may not reveal the whole picture. In a recent report in *Environmental Toxicology and Chemistry,* Relyea and two other researchers exposed nine species of tadpoles from three families to a range of concentrations of endosulfan. While endosulfan was found to be "highly toxic" to "very highly toxic" to the amphibians, there also was significant "lag mortality" in three of the nine species. For example, whereas Leopard frogs experienced no significant death during the initial four-day exposure, after an additional four days in clean water, 97% of the frogs died. Thus, even if the U.S. EPA required testing of amphibians, the traditional four-day test could completely miss the high impact of endosulfan on some species.

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This Leopard frog in Mansonville, Quebec, has no natural defense against the chemical brew that flows from lawns to ponds.
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