Sea Grant California

The effects of bifenthrin pesticide on the reproductive health of steelhead under hypersaline conditions

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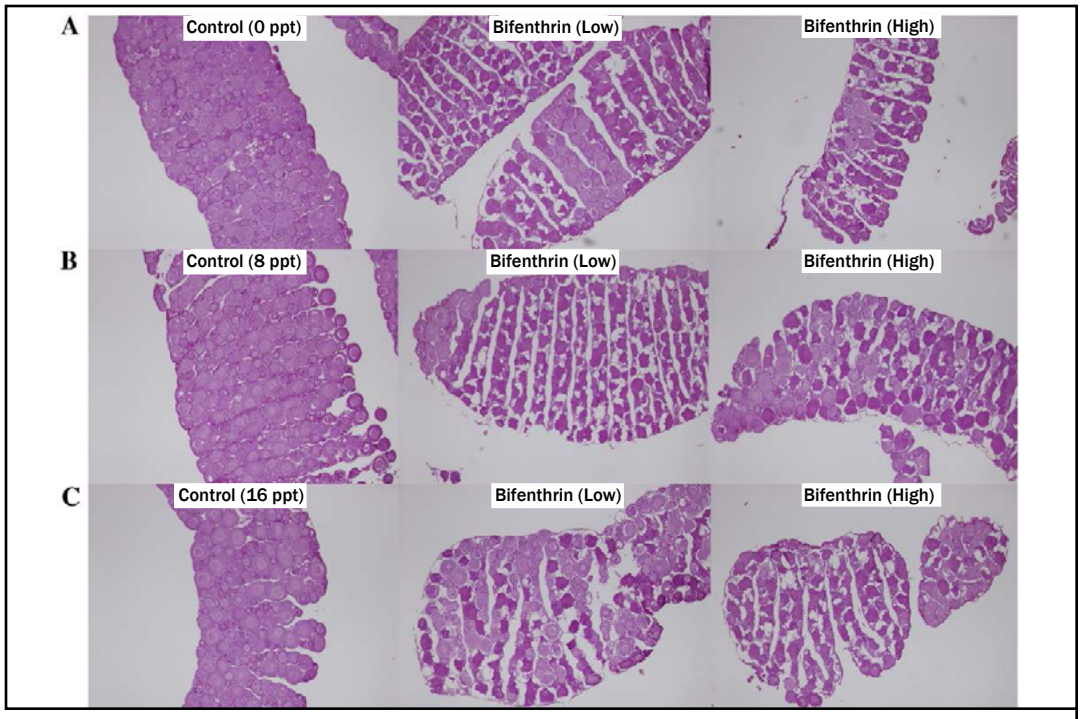
BACKGROUND

Salmon and steelhead in the San Francisco Bay-Delta face many challenges, including exposure to pesticides in runoff and municipal wastewater discharges.

Pesticides and their degradation by-products can alter hormone levels in species and may affect reproduction and behavior. Among the pesticides of great concern to managers is a class of insecticides, derived from the natural pyrethrin molecule in mums, known as pyrethroids. Though less toxic to mammals than the organophosphate pesticides they replaced, pyrethroids are highly toxic to some small aquatic species at very low concentrations.

Bifenthrin, the most commonly detected pyrethroid in the region, can be lethal to sensitive aquatic species at concentrations of 1 part per thousand (ppt) and has been detected at 19 ppt in fish spawning habitat areas.



The panel shows stained sections of ovarian tissue dissected from fish exposed to varying levels of bifenthrin and varying levels of salinity for 14 days. At both low and high exposures, bifenthrin damages the ovarian tissue of young female fish, as seen in the middle and far right columns in the panel above. [Salinity levels: A. 0 parts per thousand (ppt) water, B. 8 ppt, and C. 16 ppt.; hematoxylin and eosin staining.] IMAGE: K. Forsgren

PROJECT

This project examined the combined effects of bifenthrin toxicity and salinity exposure on the reproductive health of 4- to 6-month-old juvenile steelhead (*Oncorhynchus mykiss*) through a series of controlled laboratory experiments.

An underlying goal of the work was to explore whether young "outmigrating" salmon might be more vulnerable to pesticide toxicity because of the stress -effects of acclimating to higher-saline conditions on their migration to sea.

This question is especially relevant to the Bay-Delta, as most of the region's prime salmon streams and rivers are highly impacted by runoff and treated sewage discharges, as well as by freshwater diversions and altered hydrological cycles, related to climate change, that appear to be making waters more saline.

In the experiments, juvenile, 9- to 10-centimeter-long steelhead obtained from the Nimbus Hatchery in Sacramento were separated by sex and placed in tanks with salinities of either 0 (freshwater controls) or 4 ppt. Over the course of two days, fish were exposed to progressively higher salinities, reaching ends points of either 8 or 16 ppt. Typical seawater has salinities of about 35 ppt.

Fish were kept at the desired salinity (0, 8 or 16 ppt) for one week and then some of the males and females were exposed to low or high bifenthrin treatments, corresponding to concentrations of .1 microgram per liter (mg/L) and 1.5 mg/L. The lower bifenthrin concentration is measured in waterways in the Bay-Delta and is thus "environmentally relevant," while the higher concentration is rarely observed and represents a "what-if" scenario should contamination levels climb.

After two weeks, all groups of fish were euthanized. Their blood was collected, and sex steroids were extracted from the plasma. Gonads were dissected, weighed, sectioned, stained and analyzed.

RESULTS

The results of the laboratory experiments did not show a clear or simple relationship among higher salinity levels, higher pesticide exposure and greater endocrine-disrupting effects in fish.

Endocrine-disrupting effects were, however, elicited by pesticide exposure and these effects were most noticeable in female fish. Notably, female fish exposed to the high-bifenthrin treatments also had larger amounts of unhealthy ovarian tissue than those exposed to the low-bifenthrin treatments.

Indeed, bifenthrin could elicit opposite effects in female fish, depending on whether the fish were in fresh or salty water. For example, under freshwater conditions, bifenthrin-exposed female fish had higher plasma estradiol levels (estradiol is the natural estrogen produced by vertebrates, including humans) and increased ovarian follicle diameter than controls not exposed to the pesticide.

Under saline conditions, however, the pattern was exactly the opposite: Female fish had reduced estradiol levels and smaller follicles.

One of the surprising results of the project was the strong role of salinity in affecting female ovarian follicle diameter, as follicle diameter increased significantly at higher salinities in control groups that were not exposed to the pesticide. This pattern suggests that outmigrations might stimulate or be linked to sexual development in young females.

Another surprise was the muted response to bifenthrin exposure in male fish. The main bifenthrin-related response observed in males was a reduction in testes weight for fish in freshwater tanks. This reduction in the "gonadal somatic index," however, was the same for fish exposed to either low or high bifenthrin treatments, and under saline conditions, bifenthrin had no effect on testes size or health.

The disparity in the males' and females' responses to bifenthrin exposure may be related to the less developed stage of reproductive maturity and activity in male outmigrating fish. Immature male salmon testes contain a "type A spermatogonia" that are not actively undergoing cell division necessary for reproduction, and thus these cells may be somewhat protected from the pesticide's endocrine-disrupting effects.

The former fellow is currently identifying biomarkers of reproductive dysfunction due to bifenthrin exposure under freshwater and saline conditions. She is also assessing implications of bifenthrin exposure on fish fertilization success rates and embryo development in offspring of

MANAGEMENT APPLICATIONS

Published findings from this project show that bifenthrin contamination, as measured currently in waterways of the Bay-Delta, has the potential to reduce or damage eggs in juvenile outmigrating salmon. This could result in females having fewer offspring.

More broadly, this research has applications in evaluating the fate of common household pesticides and their effects on aquatic life in the region. Pyrethroids are especially relevant to management as they are now widely detected in surface runoff and waste-water effluent, and highly toxic to aquatic life. This project can help managers assess strategies for better evaluating and reducing the risks of these pesticides to aquatic life.

PRESENTATIONS & POSTERS

Forsgren, Kristy L., N. Riar, and D. Schlenk. (2013) The effects of the pyrethroid insecticide, bifenthrin, on steroid hormone levels and gonadal development of steelhead (*Oncorhynchus mykiss*) under hypersaline conditions. General and Comparative Endocrinology 186: 101-107.

Forsgren, Kristy L., N. Riar, and D. Schlenk. (2012) The effects of a commonly used pyrethroid, bifenthrin, on the reproductive health of steelhead (*Oncorhynchus mykiss*). SETAC North America 33rd Annual Meeting, Long Beach, Calif. Platform talk.

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