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Malformation of the Fathead Minnow (*Pimephales promelas*) in an Ecosystem with Elevated Selenium Concentrations

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Several studies have shown that fish exposed to elevated levels of selenium may develop anatomical abnormalities. Pyron and Beitinger (1989) described the development of edema in fathead minnow larvae that were produced by parents exposed to high concentrations of waterborne selenium (20 and 30 mg/l) for 24 hours. The edema was similar to that reported by Gillespie and Baumann (1986) for bluegill larvae from parents exposed to selenium in a large reservoir and Woock et al. (1987) for bluegill larvae from parents exposed for an extended period to both dietary and waterborne selenium in a laboratory experiment. Woock et al. (1987) also described other teratogenic occurrences in the bluegill larvae. Rainbow trout, after being exposed for 1 year (beginning as embryos), developed external deformities at selenium water concentrations of 80 ug/l and higher (Goettl and Davis 1976).

The purpose of this experiment was to determine if the combined dietary and waterborne selenium (water concentrations of 10 and 30 ug/l) in a seminatural ecosystem, over an extended time period, would cause abnormal development in the fathead minnow as observed in the late juvenile and early adult stages. This study was conducted in outdoor experimental streams concurrently with a bluegill-selenium toxicity study (Hermanutz et al. 1991).

MATERIALS AND METHODS

Five hundred juvenile fathead minnows from a central Minnesota pond were randomly stocked in the upper pool in each of 6 experimental streams on September 1, 1987. The streams, each 520 meters long and constructed in an alternating pool-riffle design, contained naturally colonized fish food organisms and have been described by

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Nordlie and Arthur (1981), Zischke et al. (1983) and Hermanutz et al. (1987). The streams were treated as follows: two control streams, two streams dosed with 10 ug/l selenium and two streams dosed with 30 ug/l selenium. Selenium dosing began about 6 months before the fish were introduced and continued beyond this study. For a detailed description of the chemical-physical characteristics of the streams and monitoring procedures, see Hermanutz et al. (1991).

By the spring of 1988 the fish had matured; they began to spawn in late May. Embryos were collected from each stream and incubated in the laboratory according to methods described by Mount (1968). Methods and results from the embryo-larvae portion of the fathead minnow study have been reported by Schultz and Hermanutz (1990).

On August 22, 1988 the three upper pools of each stream (approximately .01 hectares/pool) were seined several times with a 1/8 inch mesh seine in an attempt to recover all of the larger minnows. Scales of a random subsample of 30 fish were examined for annuli to determine the parent-progeny ratio. Weights and percent of malformed fish were determined from a random subsample of 78 to 490 fish (Table 1). A combined weight (standing stock) was obtained for all fathead minnows recovered in each of the streams.

RESULTS AND DISCUSSION

In the selenium-treated streams, a high incidence of malformation of the progeny of the stocked fish was observed in the collection of August 22 (scale samples showed that all were progeny of the stocked fish). Figure 1, which shows 3 fish from a 10 ug/l stream, represents the degree of malformation among the minnows in both the 10 and 30 ug/l selenium-treated streams. Table 1 gives the incidence of malformation and standing stock. The observed malformations included extended operculums, pointed snouts, exaggerated mandible angles, humped backs, and missing scales. Fish classified as malformed exhibited all of these conditions to some extent. Although the incidence of malformation in the treatments was much greater than in the control, there was no statistical difference among treatments and control because of the absence of malformed fish in one of the 30 ug/l treatment streams. The lack of malformed fish in that stream was probably due to their death prior to the August 22 collection. That stream experienced very high mortality. The standing stock in all treatment streams was lower than in the control streams (Table 1), and the standing stock in the 30 ug/l treatment was significantly lower (ANOVA, protected least-significant-difference method, $p \leq 0.05$), than the control. The

Table 1. Incidence of malformation and standing stock (combined weights) of the progeny on August 22, 1988.

	Control streams		10 ug/l Se streams		30 ug/l Se streams	
	A	B	A	B	A	B
Malformed* (%)	0.3	0	8.2	7.7	29.8	0
sample size	352	293	490	257	210	78**
Standing Stock (Kg)	16.5	11.6	10.1	7.8	3.2	0.2

*Malformations as represented by fish B & C in Figure 1.
**Total number of fish recovered.

lower standing stock was caused by smaller populations rather than smaller fish. The mean weight (N = 130) of the observed fathead minnows of all streams was 1.3 $\pm$ 1.0 grams; mean weights within treatment streams were not significantly different from those in the control streams.

Abnormalities have been reported for early life stages of fish exposed to elevated levels of selenium, as discussed in the introduction. The embryo-larvae portion of this study (Schultz and Hermanutz 1990), in which embryos collected from the 10 ug/l treatment streams were hatched in the laboratory, showed a high incidence of edema and lordosis in 4-day-old larvae (about 25% edema and 23% lordosis in the treatment vs. about 1% edema and 6% lordosis in the control).

Data are insufficient to determine at what stage the abnormalities of the older progeny first appeared. Swollen gill lamellae, distorted spinal columns, and deformed jaws and noses in older fish of several freshwater species have been observed by Lemly (1987). Some of these malformations described by Lemly are similar to those seen in the fathead minnows of this study.

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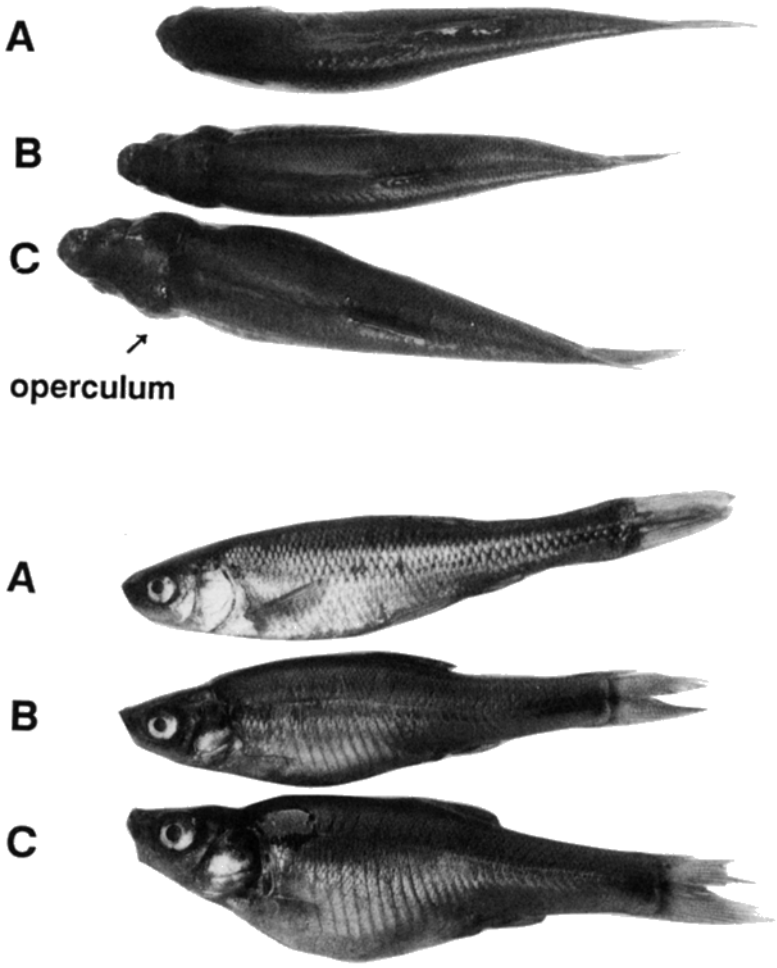

Figure 1. Top and side view of 3 fathead minnows from a 10 ug/l stream. Fish A is classified as normal, however, it may have a slightly abnormal mandible angle (lower photo). B and C are abnormal. Malformations in C are more severe than B, but both have extended operculums (top photo), pointed snout, exaggerated mandible angle, humped back where the head meets the body, nearly scaleless body, and abdominal swelling from body fluids (bottom photo). Total length of each fish was approximately 7 cm.

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