● RESEARCH

THE WEED KILLER ATRAZINE FEMINIZES FROGS

BY CAROLINE COX

When the usually conservative prestigious British science journal *Nature* headlines a news story with "Frogs put in the gender blender by America's favourite herbicide,"[1] it's hard not to take notice. The new research highlighted by *Nature*, conducted by Tyrone Hayes and his colleagues at the University of California, Berkeley, found that minute concentrations of atrazine (a tenth of a part per billion; 0.1 ppb) caused tadpoles to develop multiple sex organs or become hermaphrodites as adults. Somewhat higher concentrations (1 ppb) reduced the size of the larynx in male frogs, making it similar in size to a normal female larynx. All of us who have listened to a springtime frog chorus know how important this organ is to these animals' courtship and mating success.[2]

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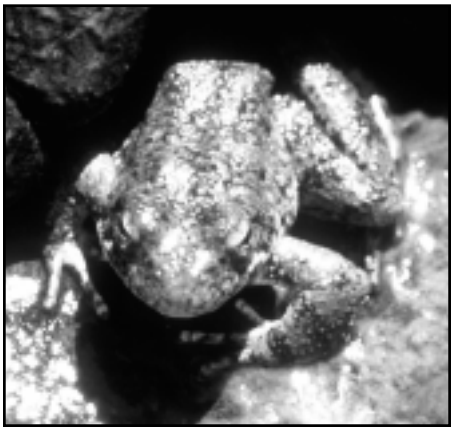

Army Corps of Engineers

"The current data raise the question of the threat of atrazine, in particular, and of pesticides, in general, to amphibians in the wild."
— Tyrone Hayes

Atrazine is one of the most widely used pesticides in the U.S. The U.S. Environmental Protection Agency (EPA) estimates annual use of this herbicide at almost 75 million pounds, mostly on corn, sorghum, and sugar cane.[3] It is also found in rivers and streams with alarming regularity. The U.S. Geological Survey (USGS), in a national monitoring project, found atrazine in over two-thirds of urban and agricultural streams, as well as in 80 percent of large rivers. Concentrations of several parts per billion are not uncommon, and it occurred at levels as high as 25 ppb.[4] "There is virtually no atrazine-free environment," said Hayes, describing the herbicide's uncanny ability to contaminate water.[5]

According to Hayes, his "current data raise new concerns for amphibians with regards to atrazine."[2] "This is not a worst-case scenario where animals are exposed to mega-doses,"[1] said University of Florida zoologist Louis Guillette.[1] The levels causing "gender blending" in frogs are levels that Hayes calls ecologically relevant,[2] levels that USGS actually found in streams and rivers.[4]

Rain is also contaminated with atrazine. In localities where it is not widely used, atrazine has been found in rain at levels of 1 ppb. In the Midwest, rain can contain up to 40 ppb of

Nature 416: 665.

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Frogs put in the gender blender by America's favourite herbicide

Rex Dalton, Berkeley

Low levels of the most widely used herbicide in the United States have been found to disrupt the sexual development of frogs. The finding will heighten concerns about the persistence of endocrine-disrupting chemicals in the environment — and throws the spotlight on another potential factor involved in the global decline of amphibian populations.

In the United States, about 27,000 tonnes of atrazine are applied each year to fields used ... as maize, sorghum and ...

...ls of atrazine cause sexual defects in leopard frogs in the US midwest?

"This is not a worst-case scenario where ... to mega-doses," says

atrazine. Both are high enough concentrations to cause the kinds of problems Hayes observed.[2]

Atrazine is usually applied in the spring, and atrazine water contamination typically peaks in that season. This makes frogs particularly vulnerable to atrazine's hormonal effects because spring is the breeding season for frogs and the season when tadpoles are developing into adult frogs.[2]

Hayes's studies were conducted in the laboratory, not with wild frogs. In addition, he used African clawed frogs, a species that is often used as a laboratory test animal and whose hormones have been well studied, rather than North American frog species. However, he has provided EPA with unpublished research from six locations in the Midwest. At these sites Hayes found wild leopard frogs with the same kind of sexual abnormalities as he had found with the African clawed frog in the laboratory.[1]

Other recent field studies that corroborate Hayes's research are a University of California, Davis, study showing that declining frog populations in California were downwind from agricultural land, and a University of Illinois study showing that intersex frogs were more common in ponds contaminated with atrazine than in uncontaminated ponds.[6,7]

Hayes believes that the reason atrazine disrupts sexual development in frogs is that the herbicide increases the activity of an enzyme called aromatase that converts testosterone, the sex hormone that predominates in males, into estrogen, the sex hormone that predominates in females. In support of this mechanism, Hayes showed that male frogs exposed to atrazine during early adulthood had lower testosterone levels than unexposed frogs. Concentrations of 25 ppb reduced testosterone levels by 90 percent, so that levels in male frogs were the same as those in unexposed females.[2]

These disruptions of sexual development may have escaped notice until now because they are essentially invisible to researchers and others. "The described effects are all internal and may go unnoticed by researchers—unlike mortality and external malformations,"[2] wrote Hayes in his article. "Exposed populations could decline and even go extinct without any recognition of the developmental effects on individuals."[2]

U.S. EPA. New England Region

"The effective levels reported in the current study are realistic exposures that suggest that other amphibian species exposed in the wild could be at risk of impaired sexual development."
— Tyrone Hayes

One of the unusual characteristics of Hayes's research is that he repeated his research a large number of times before publishing his results. He published the results of two experiments but says that he repeated the studies four times. In total he exposed frogs to atrazine 51 times and found similar results in all his studies.[2]

In addition, the frogs with multiple sex organs were uniquely associated with atrazine exposure. "These abnormalities were never observed in control [unexposed] animals," Hayes wrote, "in the current experiment or in over 10,000 observations of control animals in our laboratory over the last six years."[2]

For three of the past four years, Hayes has contracted with Syngenta, a manufacturer of atrazine, to do research for the company. However, he severed his relationship with Syngenta last year in order to independently pursue his research about atrazine's impacts on frogs.[1]

With frog populations declining around the globe,[7] Hayes's research takes on immense significance. Biologist Stanley Dodson at the University of Wisconsin called Hayes's work "the most important paper in environmental toxicology in decades." What significance does it have for people and other animals who also drink and bathe in contaminated water? We don't know," said Dodson. "It's a canary in the mine shaft sort of thing."[5] And the canary's message needs attention, now.

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