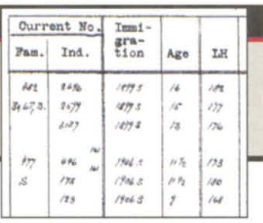

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AMPHIBIAN DECLINES

Conflict Brewing Over Herbicide's Link to Frog Deformities

A witches' brew of controversy is bubbling up over the potential link between atrazine, one of the most widely used herbicides in the United States, and the decline of amphibians. The latest additions to the brew are new findings from developmental endocrinologist Tyrone Hayes's group at the University of California, Berkeley, suggesting that exposure to very low levels of atrazine in the wild is turning male frogs into hermaphrodites. But new experimental results in another frog species, to be presented by experimental toxicologist James Carr of Texas Tech University in Lubbock and other researchers at a meeting later this month, cast doubt on such low-dose effects. At stake could be continued regulatory approval for atrazine.

Earlier this year Hayes set the kettle boiling when he reported in the *Proceedings of the National Academy of Sciences* that in the lab, male tadpoles exposed to low levels of atrazine developed into hermaphrodites or had other reproductive-organ deformities, apparently due to disruptions in their endocrine system (*Science*, 19 April, p. 447). The study used African clawed frogs (*Xenopus laevis*), known as the "lab rat" of amphibian toxicology studies. Now he's extended the finding to a native species, the leopard frog (*Rana pipiens*), in both lab and wild populations. Counterintuitively, the lowest doses of atrazine appear to be the bitterest pill for frogs. But other teams, including Carr's, say that they have been unable to replicate Hayes's original *Xenopus* findings.

Atrazine is used throughout the world in countries that are major corn growers, according to Timothy Pastoor, head of global risk assessment for Syngenta, a major producer of atrazine. Several countries in Europe have banned the compound but not directly due to health concerns. The countries have a policy of banning any questionable pesticide that occurs in drinking water at levels higher than 0.1 parts per billion (ppb).

The U.S. Environmental Protection Agency (EPA) is currently reevaluating the risk that atrazine could affect human or ecological health at environmental levels. The possible link between atrazine and reproductive-organ abnormalities in frogs is so important to this reevaluation that the agency is delaying the process to convene a specially selected panel of scientists to evaluate the available data, according to an EPA spokesperson. Amphibian populations have been declining precipitously in the past decade or more, ecologists have reported, and Hayes and others have proposed that widespread use of atrazine could contribute to the problem. Syngenta, meanwhile, has been sponsoring an independent, multimillion-dollar research program into the potential effects of atrazine in the environment on animals' endocrine systems. The Carr study is funded through this program.

Digging up trouble. Tyrone Hayes, here building frog traps in Nebraska, finds that atrazine makes male frogs hermaphroditic.

Hayes says that his new study shows the real-world dangers of atrazine: "This isn't just about an amphibian 'lab rat' anymore." The paper, published in this week's issue of *Nature*, "is very provocative and we are taking it very seriously, but we need to see more data," says a senior EPA scientist who requested anonymity. Many experts who are familiar with the studies would only speak anonymously, citing concern that their comments might bar them from consideration for EPA's review panel.

Hayes's team exposed *Rana* tadpoles in the lab to one of two doses of atrazine. The testes of some exposed males contained oocytes—eggs that should only be found in female frogs—or were underdeveloped. A higher proportion of males, 29%, had testes containing oocytes at the lower dose, 0.1 ppb; 8% of the frogs exposed to 25 ppb were abnormal. (Drinking water in the United States is allowed to have up to 3 ppb atrazine.)

Hayes's team suggests that atrazine disrupts male frogs' hormones by inducing production of aromatase, an enzyme that converts androgens into estrogens. Endocrine disrupters often have more marked effects at lower doses, according to zoologist Louis Guillette of the University of Florida, Gainesville.

The team also examined 800 newly metamorphosed *Rana* from eight sites across the western and midwestern United States. They found hermaphrodite males at the seven sites with water-borne atrazine contamination higher than 0.2 ppb. The highest proportion of abnormalities, 92%, was recorded from a relatively pristine site in Wyoming. The one site with no measurable amounts of atrazine hosted healthy frogs.

But toxicologist Keith Solomon of the University of Guelph, Ontario, Canada, one of the members of the Syngenta-sponsored team, argues that the results show no meaningful link between atrazine exposure and abnormalities. Low levels of atrazine don't induce aromatase in frogs, he claims. Without the aromatase link, "there should be a correlation between dose and response. But the highest proportion of abnormalities were found at a site with atrazine levels close to background. On this basis how can the cause be atrazine?" As for the lab-based findings, "if this effect is robust, [our] new laboratory study on *Xenopus* should produce clear results—it doesn't," he says.

Carr's team, like that of Hayes, exposed *Xenopus* tadpoles to atrazine until they completed metamorphosis. They found an effect, "but the results were only statistically significant at the highest dose, nominally 25 ppb, but actually 19 to 21 ppb based on water measurements," he says. A third, unpublished, Syngenta-sponsored study conducted in zoologist John Giesy's lab at Michigan State University, East Lansing, found a similar proportion of abnormalities in control and atrazine-treated frogs, says Carr. In addition, "field studies of *Xenopus* in South Africa—the

CREDIT: AARON VONK

frog's native habitat—show no response," says Solomon. Results of the Carr study and the South African field studies are to be presented at the Society of Environmental Toxicology and Chemistry annual meeting in Salt Lake City, Utah, 16 to 20 November.

The EPA atrazine docket, a publicly available record of comments about atrazine reregistration, reveals that the Hayes and Carr teams have been swapping detailed and pointed critiques about each other's studies. But an amphibian toxicologist not involved in either effort suggests that the complexity of long-term amphibian studies might account for some of the discrepancies. "These three studies are from good labs," he says, adding, "there's a lot that we don't understand about simple things." The researcher says that it's not clear if any of the seemingly minor differences between the Hayes and Carr protocols matter, such as the different strains of frogs, densities of tadpoles, or materials used to build the tanks. Such is the witches' brew of ingredients that the EPA panel will ponder. **–REBECCA RENNER**

Rebecca Renner is a writer in Williamsport, Pennsylvania.

FISHERIES SCIENCE

Scientists Recommend Ban on North Sea Cod

CAMBRIDGE, U.K.—In what could prove to be a serious blow to Europe's ailing cod-fishing industry, fisheries scientists last week advised the European Union (E.U.) to ban cod fishing in the North Sea and several other historic regional trawling grounds. But economic pressures might lead politicians to tone down the advice.

The recommendation is based on surveys suggesting that major cod stocks in the northeast Atlantic are at historic lows. European fishing quotas for 2003 are due next month, and scientists say that a ban is the only way to protect future stocks. "Populations will collapse if there are not drastic reductions in fishing," says Robin Cook, director of the Fisheries Research Services Marine Laboratory in Aberdeen, United Kingdom.

But some researchers wonder whether politics will trump science, noting that a ban could cost 20,000 jobs in the United Kingdom alone. "I would be delighted but shocked if [the European Commission] agrees to all the needed restrictions," says Andrew Rosenberg, a former chief fisheries regulator in the United States and now a dean at the University of New Hampshire, Durham. Other researchers predict that even quick action might not restore healthy stocks soon.

Europe's cod drama reprises one that gripped North America in the last decade, when groundfish stocks collapsed in the western North Atlantic and subsequent fishing bans devastated U.S. and Canadian fleets. European fishers are now following the same chart, says the Copenhagen-based International Council for the Exploration of the Sea (ICES), which advises the European Commission on fisheries. According to scientific surveys and catch statistics, the North Sea's cod spawning schools have dropped to just 15% of what they were in the early 1970s. "The stock is half of the absolute minimum" needed to sustain healthy populations, says Hans Lassen, ICES's fisheries adviser.

Even with a ban, hard-hit stocks might not bounce back quickly. Some Canadian populations haven't recovered even after a decade of restrictions, notes fisheries scientist Jeffrey Hutchings of Dalhousie University in Halifax, Nova Scotia, Canada. U.S. stocks have fared better, as the fisheries were closed before populations plummeted to unsustainable levels and the fish mature faster than their northern cousins.

The European stocks appear to share some of that robustness, says Hutchings, although dwindling numbers "raise major worries." The U.K.'s Cook agrees: "We're right on the end of the graph," he says, predicting that it will take at least 4 years to rebuild fishable cod populations.

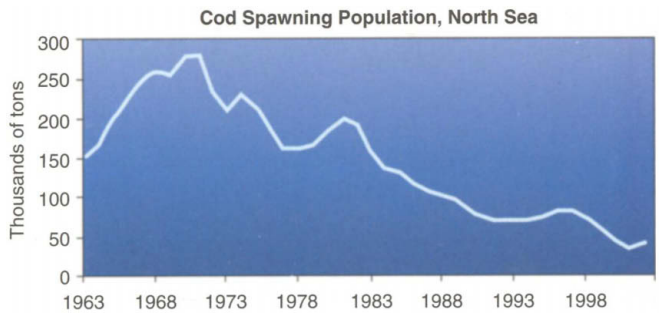
A cod ban could also harm other fleets. That's because ICES has recommended banning vessels that target other species—such as haddock or shrimp—but also net cod as so-called bycatch. "You cannot look at the cod in isolation," says Lassen.

Rosenberg is skeptical that politicians will crack down on bycatch. The enormous economic implications of that move, he notes, have led policy-makers to ignore ICES recommendations in the past, "making the hole they are in now even deeper." Still, he hopes that E.U. officials will create some "closed areas that are big enough to provide the fish with a substantial refuge."

Off the menu? Atlantic cod was once a staple of European diets.

Industry is pleading for less drastic steps. George MacRae of the Scottish white fish producers association told *The Guardian* last week that a sweeping ban "is the doomsday scenario." Policy-makers now face the slippery task of balancing the future of the fish against that of the fishers.

–DAVID MALAKOFF AND RICHARD STONE



Smaller schools. The number of spawning cod in the North Sea has sunk to record lows, imperiling the fishery.

CREDITS: (TOP TO BOTTOM) LAWSON WOOD/CORBIS; SOURCE: ICES

ASTRONOMY

Iron Deficiency Reveals Nearly Pristine Star

Astronomers have found an ancient star that preserves a chemical record of the infant cosmos. The little star, just now facing the end of its long life, suggests that the first stars in the universe might not all have been the colossi that models predict. "It's astounding that we can glimpse such an early stage of the universe through the composition of this star," says astronomer Catherine Pilachowski of Indiana University, Bloomington.

Stars are relentless element factories,