Rachel's Environment & Health News
#545 - Fish Sex Hormones
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In the early 1990s, British researchers at Brunel University in Uxbridge noticed that male fish living downstream from a sewage treatment plant near London had testes laden with eggs. The male fish had become hermaphrodites (also known as intersex --having the sexual characteristics of both males and females).[1]

Subsequently, when caged trout were placed downstream from sewage treatment plants in several British rivers, the males were discovered to have elevated levels of a protein called vitellogenin in their blood.[2] Vitellogenin is the protein responsible for making egg yolks in female fish. Ordinarily, little, if any, vitellogenin is found in the blood of male fish.[3] Male fish have a gene which, if triggered by estrogen (female sex hormone) can produce vitellogenin, but male fish ordinarily lack sufficient estrogen to trigger the vitellogenin-making gene.

British researchers John Sumpter and Susan Jobling then reported that male trout caged downstream from sewage treatment plants throughout England showed the telltale vitellogenin in their blood, indicating that something coming out of sewage treatment plants was having an estrogenic effect on the fish.[3] Every sewage treatment plant in England caused the estrogenic effect. It took only 2 to 3 weeks for the vitellogenin to begin to appear in the blood of caged trout.

The British researchers tested a few common industrial chemicals to see if they could stimulate the production of vitellogenin in male trout under laboratory conditions. They found that several common industrial chemicals could do the trick, and could do it in a dose-dependent way: the more chemical the male trout were exposed to, the more vitellogenin they produced.

Chemicals found to induce vitellogenin in males included octylphenol and nonylphenol (both alkyl phenols, which are commonly used in detergents, toiletries, lubricants and spermicides); bisphenol-A (the building block of polycarbonate plastics); o,p'-DDT (the common pesticide, banned in the U.S. but still widely used in some industrializing parts of the world); and Arachlor 1221 (one of the 209 varieties of PCBs, or polychlorinated biphenyls --common industrial chemicals now banned in the U.S. but still widely found in the environment).[3]

These same researchers then tested mixtures of these chemicals. They showed that mixtures were more powerful at producing vitellogenin than any of the individual chemicals alone. They thus demonstrated conclusively under laboratory conditions that these chemicals, at levels commonly found in British rivers, could induce vitellogenin in male fish.[3]

They found that the chemicals tended to bioconcentrate in the flesh of the fish; in other words, as time passed, the concentration of the chemicals increased. Thus even low concentration of a weakly estrogenic chemical could eventually build up to a level that induced vitellogenin production in male fish.

Sumpter and Jobling then asked themselves whether the estrogen effects of these chemicals would be limited to one species. After reviewing available literature and conducting a limited number of experiments themselves, they concluded that, "Most evidence supports the idea that if a chemical is estrogenic in one species, it will be in all others."

Sumpter and Jobling then asked themselves what are the consequences for aquatic organisms (such as fish) living in a "sea of estrogen." The answer, they said, is easy: we do not know. The possible effects are "almost endless," they said, because of the large number of roles played by natural estrogens. They did pinpoint reproduction as the process mostly likely to be disrupted and they said it is "probable that these changes [production of vitellogenin in males] from the normal pattern will adversely affect reproduction."

In late 1996, U.S. researchers published studies confirming that up-to- date sewage treatment plants in the U.S. can cause the same effects in fish living downstream.[4] Scientists with U.S. Environmental Protection Agency, Tulane University, the University of Florida, and the Minnesota Department of Natural Resources examined male carp from five locations in the Mississippi River downstream from the Minneapolis sewage treatment plant, and from a tributary, the Minnesota River, which receives heavy agricultural runoff. For comparison, they captured male carp from the St. Croix River, which is classified as a National Wild and Scenic River and is not heavily contaminated.

They found that carp living near the Minneapolis sewage treatment plant showed "a pronounced estrogenic effect," namely the production of vitellogenin and reduced levels of testosterone (male sex hormone). Carp from the pesticide-contaminated Minnesota River had sharply- reduced testosterone levels but showed no vitellogenin effect. Carp from the St. Croix River were normal.[4]

The U.S. Geological Survey (USGS) reported in April that industrial contaminants in many U.S. rivers and lakes seem to be affecting the levels of sex hormones in fish throughout the U.S.[5] "The finding of a correlation between hormone levels and contaminant levels in fish from such diverse locations is both a cause for concern and a call for further investigation," said Dr. Gordon Eaton, director of USGS, releasing the study.

The study was conducted by USGS in collaboration with the National Biological Service (now the Biological Resources Division within USGS) and the University of Florida.

The study analyzed 647 carp collected from 25 streams (including 11 major rivers, such as the Mississippi, the Columbia, and the Hudson) in 13 states and the District of Columbia. The streams were selected based on the kind of area they drain; the goal was to select streams that represented environmental settings that are typical of major regions of the nation.

The fish were tested for estrogen and testosterone (female and male sex hormones) in their blood. All fish have both estrogen and testosterone in their blood; however, the ratio of the two hormones varies between females and males. The ratio is important. As Bette Hileman has said, "In the developing fetus of both humans and animals, a specific ratio of estrogen to androgens (male hormones [such as testosterone]) is necessary for sexual differentiation [the process of developing into a male or a female]. If the ratio is perturbed, the offspring may be born with two sets of partially developed sexual organs (intersex) or with a single set that is incomplete or improperly developed."[6]

In addition to testing for the estrogen/testosterone ratio, USGS also tested carp for organochlorine pesticides and PCBs [polychlorinated biphenyls] in their blood. Organochlorine pesticides (such as DDT, aldrin, and dieldrin) and PCBs are known to affect hormone levels in wildlife.[4]

Furthermore, at sites where fish were captured, USGS took samples of sediments and analyzed them for total phenols, phthalates, and polycyclic aromatic hydrocarbons (PAHs); all three of these classes of chemicals are known to affect hormones in wildlife. (Phenols, as we saw above, have many uses; phthalates are widely used in plastics; PAHs are produced by combustion of gasoline, oil, coal, garbage, medical and hazardous wastes, and by metal smelters.)

USGS concluded that its most significant findings included these:

** At half the locations tested, one or more male carp were producing vitellogenin at low levels.

** In both male and female carp, the estrogen/testosterone ratio was most disturbed by dissolved pesticides in water. The site with the highest level of dissolved pesticides (the Platte River at Louisville, Nebraska) had the lowest estrogen/testosterone ratio.

** For both male and female carp, the presence of phenols was associated with reduced levels of both estrogen and testosterone.

USGS researchers said their study was too crude to actually determine that specific contaminants were causing specific changes in the sex hormones of fish. However, as noted above, the agency said the findings were "cause for concern."

It is apparent that many waters of the U.S. contain substances that can alter the sex hormones of fish. The implications are clear: whatever is altering the sex hormones of fish originates on the land, and is caused by human activities. Because estrogen and testosterone perform many of the same functions in fish, birds, amphibians, reptiles, and mammals (including humans), mans), there is no reason to believe (or even hope) that humans are exempt from the chemicals that are altering the fish.

One might think --based on common sense and simple prudence --that it would be appropriate to begin controlling hormone-disrupting chemicals. Unfortunately, U.S. EPA has adopted the position of the Chemical Manufacturers Association (CMA), which is this: merely altering the sex hormones of fish OR EVEN HUMANS is not sufficient reason to initiate controls on known hormone-disrupting chemicals. It is up to us (the public) to prove that altering our sex hormones is bad for us (causing "adverse effects" is how EPA expresses it).[7] It will take many decades, perhaps centuries, to gather the necessary evidence to convince the likes of the CMA (the permanent government[8]) that an "adverse effect" has occurred. Think of the history of tobacco. In the meantime, with EPA's blessing, the chemical industry will continue to do its business in our water.

--Peter Montague (National Writers Union, UAW Local 1981/AFL-CIO)

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[1] Jocelyn Kaiser, "Scientists Angle for Answers," SCIENCE Vol. 274 (December 13, 1996), pgs. 1837-1838.

[2] John P. Sumpter, "Feminized responses in fish to environmental estrogens," TOXICOLOGY LETTERS Vol. 82-83 (Dec., 1995), pgs. 737-742. See also: C. Purdom and others, "Estrogenic Effects of Effluents From Sewage Treatment Works" CHEMISTRY AND ECOLOGY Vol. 8 (1994), pgs. 275- 285. And see: S. Jobling and J. Sumpter "Detergent components in sewage effluent are weakly oestrogenic to fish: an IN VITRO study using rainbow trout (ONCORHYNCHUS MYKISS) hepatocytes" AQUATIC TOXICOLOGY Vol. 27 (1993), pgs. 361-372.

[3] John P. Sumpter and Susan Jobling, "Vitellogenesis as a Biomarker for Estrogenic Contamination of the Aquatic Environment," ENVIRONMENTAL HEALTH PERSPECTIVES Vol. 103, Supplement 7 (October, 1995), pgs. 173- 177.

[4] Leroy C. Folmar and others, "Vitellogenin Induction and Reduced Serum Testosterone Concentrations in Feral Male Carp (CYPRINUS CARPIO) Captured Near a Major Metropolitan Sewage Treatment Plant," ENVIRONMENTAL HEALTH PERSPECTIVES Vol. 104, No. 10 (October 1996), pgs. 1096-1101.

[5] Steven L. Goodbred and others, RECONNAISSANCE OF 17BETA-ESTRADIOL, 11-KETOTESTOSTERONE, VITELLOGENIN, AND GONAD HISTOPATHOLOGY IN COMMON CARP OF UNITED STATES STREAMS: POTENTIAL FOR CONTAMINANT-INDUCED ENDOCRINE DISRUPTION [U.S. Geological Survey Open-File Report 96-627] (Denver, Colorado: U.S. Geological Survey, 1997). Available for $7.75 (prepaid) from: U.S. Geological Survey, Branch of Information Services, Box 25286, Denver federal center, Denver, CO 80225. The report is also available on the world wide web at: http://water.wr.usgs.gov.

[6] Bette Hileman, "Environmental Estrogens Linked to Reproductive Abnormalities, Cancer," C&EN [CHEMICAL & ENGINEERING NEWS] January 31, 1994, pgs. 19-23.

[7] EPA's position is clearly stated in Thomas M. Crisp and others, SPECIAL REPORT ON ENVIRONMENTAL ENDOCRINE DISRUPTION: AN EFFECTS ASSESSMENT AND ANALYSIS [EPA/630/R-96/012] (Washington, D.C.: Environmental Protection Agency, Risk Assessment Forum, February, 1997). Available via the internet: http://www.epa.gov/ORD/WebPubs/endocrine/ .

[8] See REHW #517.

CELEBRATING BARRY COMMONER'S WORK

To celebrate Barry Commoner's 80th birthday, a group of his friends and colleagues have organized a day-long symposium in New York City May 30th, titled "Barry Commoner's Contribution to the Environmmental Movement: Science and Social Action." The purpose is to draw lessons from the past and create momentum for a strong future for the environmental movement. The public is invited. It is free. Speakers will include Ralph Nader, Tony Mazzocchi, John O'Connor, Peter Bahouth (invited), Judi Enck, Dan Kohl, Virginia Brodine, Eric Goldstein, Vernice Miller, Taghi Farver, Giovanni Berliguer, Chicco Testa. David Cleverly, Peter Montague, and others. Barry himself will end the day with a talk titled, "What Is Yet To Be Done." The symposium starts at 9 am May 30th in the Great Hall at Cooper Union (7 East 7th Street between 3rd and 4th Avenues). Contact: Sharon Clark Peyser, CBNS, Queens College, Flushing, NY 11367; telephone (718) 670-4180; fax (718) 670-4189. Hope to see you there! --P.M.

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