Sex change

Are hormones in sewage really posing a risk to fish populations? Will better sewage treatment help? **Peter Matthiessen's** 'before and after' study of the river Ray aims to find out.

Many male fish in rivers and estuaries worldwide are developing female characteristics, because of exposure to natural and synthetic hormones that enter rivers in sewage. Indeed, the concept of polluted fish with dubious sexuality has almost passed into folklore, with a host of risqué cartoons and popular articles.

But does this phenomenon really matter to fish populations in the wild, or is it all just a storm in an academic aquarium? Does it actually make any difference to fish populations if a significant proportion of male fish are feminised to varying degrees? Will new sewage-treatment technology to remove oestrogens lead to ecosystem recovery in an affected river? And which river systems would benefit most from the introduction of this technology? A consortium of research centres and universities has just started a new research programme—Endocrine Disruption in Catchments (EDCAT)—to answer some of these key questions.

The phenomenon of intersexuality in male fish includes a spectrum of effects: the presence of yolk protein in the blood, changes in secondary sexual characteristics, production of egg cells and oviducts, and ultimately, to a complete apparent sex change.


2


1

Both pictures: Monika Jürgens

1 *Electro-fishing uses mild electrical pulses to temporarily stun fish such as sticklebacks and roach.*

2 *Electro-fishing catch.*

3 *The roach* Rutilis rutilus.

Tom Pottinger

Ground-breaking research at Exeter and Brunel universities has previously shown that the sperm from intersex roach *Rutilus rutilus* are less viable than those from normal fish when used to fertilise eggs in the laboratory. Computer modelling at the Centre for Ecology & Hydrology (CEH) has been used to identify reaches in a catchment where fish are most at risk from endocrine disruption. In many reaches in the UK a high proportion of fish are intersex.

Experiments at the University of Exeter found that long-term exposure to the contraceptive oestrogen ethinylestradiol, found in sewage effluent, causes male roach to become permanently intersex. And NERC-funded PhD student Richard Maunder of CEH has demonstrated that briefly exposing fry of the three-spined stickleback *Gasterosteus aculeatus* to concentrations of ethinylestradiol already found in the natural environment, from both natural and man-made sources, has long-term consequences for the adults even though they are grown on in clean water. In brief, freely breeding populations of these sticklebacks make fewer nests and produce fewer viable eggs than the controls.

Attributing causes to effects in pollution-related fieldwork is not easy, but we are taking advantage of the pilot Endocrine Disrupter Demonstration Programme—being run by the Environment Agency and the water industry—to study the river Ray in Wiltshire. The Ray will benefit from cleaner effluent in 2008 after sewage treatment with granular activated carbon to remove oestrogens and certain other pollutants. As it happens, the sewage entering the Ray comes from the town of Swindon, so NERC's effluent is under direct examination for the first time!

We are planning to do field and lab studies of roach and three-spined stickleback in the river Ray both before and after Swindon's sewage effluent gets its new treatment. These experiments will be closely coordinated with measurements of oestrogens and other contaminants in the Ray. The results will be used to improve computer models of oestrogen exposure, predicting the time and location of pollution 'hot spots'.

Innovative experiments will take intersex male roach from the Ray and allow them to breed freely in large tanks with normal females, in competition with normal males. Genetic fingerprinting will identify the parents of each offspring, so that we can estimate the breed true success of intersex roach in the river. Simultaneously, ecologists will be monitoring the population structure of wild sticklebacks in the Ray.

We will also be using biomarkers to examine the responses of wild sticklebacks both to endocrine disrupters (oestrogens and chemicals that interfere with male hormones such as testosterone) and to other pollutants which might affect the results. These biochemical and physiological markers—some of which have been developed for sticklebacks by the Centre for Environment, Fisheries and Aquaculture Science (Cefas)—can tell us the degree of exposure of the fish to hormone-disrupting substances and other chemicals, and the severity of their responses.

We don't yet know enough about the ecological effects of hormone-disrupting pollutants to say whether the huge investments required to upgrade sewage treatment works will result in commensurate benefits in specific rivers. The collaborative and interdisciplinary EDCAT programme should take us a lot closer to understanding and predicting the environmental threats of hormone-disrupting pollutants in our rivers. This should ensure that expensive technology to remove these pollutants can be sited at the sewage treatment works which most need it.

Want to know more?
Full details of the programme are at www.ceh.ac.uk/EDCAT

Professor Peter Matthiessen, who coordinates the EDCAT programme, is at the Centre for Ecology & Hydrology, Lancaster Environment Centre, Library Avenue, Bailrigg, Lancaster LA1 4AP, tel: 01524 595867, email: pmatt@ceh.ac.uk.

EDCAT project leaders include Andrew Johnson at CEH Wallingford (exposure modelling), email ajo@ceh.ac.uk; Jan Balaam at Cefas Burnham (exposure measurements), email: j.l.balaam@cefas.co.uk; Tom Pottinger at CEH Lancaster (stickleback studies), email: tgp@ceh.ac.uk; and John Sumpter at Brunel University (roach experiments), email: john.sumpter@brunel.ac.uk.

The Centre for Ecology & Hydrology, Centre for Environment, Fisheries and Aquaculture Science, Plymouth Marine Laboratory and the Universities of Exeter, Brunel and Sussex are collaborating in EDCAT. The programme is funded by the Department for Environment, Food and Rural Affairs, the Environment Agency and United Kingdom Water Industry Research Limited, with contributions in kind from the collaborating institutes.