

## Introduction: The Ecological Relevance of Chemically Induced Endocrine Disruption in Wildlife

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Over the last two decades, there has been increasing scientific concern and public debate regarding the adverse effects of chemical pollutants in the environment that can interfere with the normal functioning of the endocrine system in wildlife and in humans (the so-called endocrine-disrupting chemicals, EDCs). These concerns have been fueled primarily by reports of disrupted reproductive function and development in certain wildlife—mammals, birds, fish, amphibians, and mollusks—and by the increased incidence of certain diseases of the endocrine system in humans. Investigators hypothesize that EDCs are the cause. Some of the adverse effects observed in wildlife species are strongly associated with exposure to chemicals that mimic or interfere with hormone function, particularly estrogen function, but in many cases, the causal link between exposure to EDCs and endocrine disruption is unclear. Because of the diverse effects of EDCs on the thyroid, retinoid, androgen, estrogen, and corticosteroid systems of a wide range of animals, it is imperative that research continues to address the extent of the risk posed by EDCs to wildlife. The ecological relevance of endocrine disruption in wildlife is, however, difficult to quantify, as there is limited understanding of how physiological changes affect the individual animal and how individual responses affect population and community. Furthermore, a major challenge faced by environmental biologists is the need to place endocrine disruption into context with other environmental pressures faced by our wildlife populations, for example, global warming.

In July 2004 an international workshop was convened at the University of Exeter in the United Kingdom to provide a forum for the dissemination and discussion of the most recent data on the ecological relevance of chemical-induced endocrine disruption in wildlife. The workshop was organized by the COMPRENDO Project (Comparative Research on Endocrine Disruption; COMPRENDO 2006). COMPRENDO is one of four projects [COMPRENDO, EDEN (Endocrine Disruptors: Exploring Novel Endpoints, Exposure, Low-Dose and Mixture-Effects in Humans, Aquatic Wildlife and Laboratory Animals), EURISKED (Multi-organic Risk Assessment of Selected Endocrine Disruptors), FIRE (Risk Assessment of Brominated Flame Retardants As Suspected Endocrine Disruptors for Human and Wildlife Health)] that form the research laboratory core (comprising 60 laboratories) of the CREDO (Coordinating European Environmental and Human Research into Endocrine Disruption) cluster for research, technological development, and demonstration activities in the European Community (CREDO 2006). CREDO is funded by the European Commission's Fifth Framework Programme. One hundred-eighty delegates attended the meeting from 20 countries spanning Europe, the United States, Japan, India, and South Africa and representing many stakeholders including academia, government agencies, industry, and nongovernment agencies. The meeting proceedings are available on the World Wide Web (COMPRENDO 2004).

This monograph contains a synthesis of papers presented at the Exeter meeting and presents novel research data and new thoughts and approaches on the ecological relevance of endocrine disruption in wildlife. The first article by Guilleter (2006) discusses how the issue of endocrine disruption has developed in complexity, as we now appreciate that a plethora of chemicals are capable of altering hormonal function through a wide range of mechanisms of action. Understanding the effects

of EDCs on wildlife populations requires carefully conducted field studies spanning a number of years. Such studies are unfortunately few and far between. Exceptions to these limited studies are those on the effects of organotin compounds on populations of marine mollusks and estrogenic disruption in marine and freshwater fish living in the coastal and riverine waters of the United Kingdom. The latest findings and hypotheses in these studies are presented by Horiguchi et al. (2006), Hagger et al. (2006), Scott et al. (2006), Jobling et al. (2006), Hayes et al. (2006a), Veeramachani et al. (2006), and Hall et al. (2006). These case studies illustrate some of the challenges encountered when establishing cause-effect relationships between chemical exposures and physiological function in diverse species. Hagger et al. (2006), in particular, consider the associated genotoxic effects of endocrine-disrupting chemicals on mollusks, perhaps expanding the mechanisms by which EDCs induce harm in wildlife, while Jobling et al. (2006) and Hall et al. (2006) use modeling approaches to delineate the relative risks posed by different EDCs on wildlife populations and to identify likely causative agents. Hayes et al. (2006a) rise to the ultimate challenge and address the likelihood that EDCs are responsible for the widespread population declines in amphibian populations worldwide. Veermachani et al. (2006) describe testis and antler dysgenesis in Sitka deer on the remote Kodiak Island of Alaska and draw on this as further evidence to support the endocrine disruption hypothesis linking testicular dysgenesis in men with reproductive dysfunction in other male wildlife. Finally, in this section on field studies, Durhan et al. (2006) take the reader beyond the dogma surrounding estrogens in the environment and present powerful evidence for the presence of androgenic contaminants in runoff from beef feedlot. The authors identify the causative agents as metabolites of the growth promoter trenbolone acetate.

Most laboratory studies on chemical effects have been conducted on single chemicals, but in the wild, animals are often exposed to complex mixtures that potentially have interactive effects. The next two articles are derived from field studies and provide evidence for interactive effects of EDCs with other environmental factors. Edwards et al. (2006) examine interactive effects of water quality on reproduction in mosquito fish, and Jessen (2006) discusses the potential for interaction of EDCs with climate change in Arctic marine mammals and birds. The following two articles on mixture effects are laboratory-based studies. Liney et al. (2006) consider the integrative effects of estrogenic effluents from wastewater treatment works on roach health (spanning sexual function, immunotoxicity, hepatotoxicity, and genotoxicity). Thorpe et al. (2006) assess the ability of the model of concentration addition to predict the interactive effects of estrogenic chemicals in a complex mixture (wastewater treatment works effluent) and conclude that end-pipe analysis may be the preferred approach for assessing the effects of these complex mixtures.

Human toxicology studies focus on the protection of the individual, but studies in ecotoxicology wildlife protection are directed principally

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This article is part of the monograph "The Ecological Relevance of Chemically Induced Endocrine Disruption in Wildlife."

In addition to employment at Brunel University, S. Jobling is also employed by Beyond the Basics Ltd., an independent consultancy. C. Tyler declares he has no competing financial interest.

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