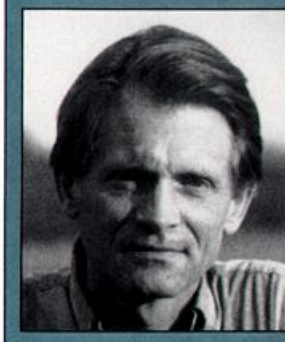
Ignore the staggering fact that the world's ecosystem is contaminated by persistent, bioaccumulative chemicals, and you risk missing the truth.

J. P. Myers

FACTS, INFERENCES AND SHAMELESS SPECULATIONS



Science Blindsided

BIRD MIGRATION may be far more malleable in the face of strong natural selection than anyone would have dared posit. Or so new research from Germany would indicate... if you accept the analysis as complete.

It may be. The work, by Peter Berthold, A.J. Helbig, G. Mohr and U. Querner (*Nature*, Vol. 360: pp. 668–669) is elegant and appears decisive, save that they have ignored a crucial alternative interpretation. Because their conclusions are extraordinary—not just for basic science but also for conservation—they've got a few more nails to drive in before we can elevate their findings to the pantheon of scientific truths.

The background: Fewer than 40 years ago, Blackcaps (*Sylvia atricapilla*) breeding in Germany rarely, if ever, wintered in England, traveling to Africa during autumn migration. Beginning in the 1950s, British birders began noting more and more Blackcaps remaining through the winter. Banding revealed they were coming from Germany. Currently seven to eleven percent of German and Austrian-breeding Blackcaps go to England instead of Africa.

The new results: Berthold and his colleagues, whose studies of the genetics of migration have revolutionized our understanding of that field, went to work. They captured some Blackcaps from England in the winter and took them back to Germany, where they allowed the birds to reproduce in captivity. Parents and offspring were separated and put in cages, during fall migration, that were designed to reveal the direction the birds would have migrated had they been free to fly.

Lo and behold, England-wintering parents and their young chose migratory orientations that would have taken them to England. Birds captured in Germany by contrast, oriented toward Africa.

For Berthold, the crucial finding was that both English-caught parents and young orient toward England. Steeped in genetic studies of migration, he reached the obvious conclusion: The differences between English-caught and German-caught Blackcaps were genetic in nature. Because observations from England report a large expansion in the numbers of British-wintering Blackcaps over a very short period, he concluded that the changes amount to an evolutionary change in migratory behavior—that is, that the genotype of English-wintering birds had increased in frequency in the breeding population.

Why does this matter? Berthold's results imply that bird migration can evolve rapidly in the face of environmental change. Given what the globe will look like in 40 years, I would desperately like this to be so. Otherwise, we face the unraveling of many bird migration systems in our lifetime.

Where did he go wrong? The flaw in Berthold's conclusion is his assumption that the orientation differences are based on genetic differences. *They*

may well be, but Berthold *et al* have ignored a whole class of alternative, non-genetic hypotheses that are at least as plausible as those they claim. These alternatives are all variations on one theme: maternally-transmitted contamination of behavioral toxicants that distort development.

What does that mean? Humans are spreading a host of nasty chemicals throughout the planet, and their diffusion has been dramatic over the same time period that Blackcaps' migratory behavior has changed. No ecosystem is so isolated to be immune or unaffected. Some compounds are particularly insidious because they interfere with development. Passed from mother to young as the embryo develops, they distort the chemical processes that translate genes into organism.

It is entirely plausible that contamination in parts of the German environment, passed up the food chain to Blackcap mothers and to their eggs and young, is altering migration. If the contaminant is not evenly spread over Blackcaps' entire breeding range, then you would expect to see some parts of the population behaving differently than others. If the contamination levels are not changing rapidly, then what Mother Blackcap received from her mother would be similar to what she passed on to her progeny, and they would therefore behave similarly. The net result would blind side genetic researchers until they were able to do far more involved research, which to date Berthold *et al.* have not reported.

There are gaping holes in this explanation, no doubt about it. But it cannot be rejected out of hand. It is at least as likely as rapid evolutionary change, and provides some interesting challenges to migration researchers and conservationists.

Before I get to the holes, consider the impacts of "xenobiotic estrogens." These compounds are synthetic chemicals that distort development through their ability to interfere with the activities of estrogens The list of "xenos" includes a host of nasty substances like organochlorine pesticides, PCBs, dioxin, diethylstilbestrol, etc. [A new book just out (*Chemically Induced Alterations in Sexual and Functional Development: the Wldlife/Human connection;* T. Colborn and C. Clement (eds.) Princeton Scientific Publ. Co., 1992) provides an immense amount of scientific background for how, when, and where xenos work.]

Xenos' effects are not trivial. They range from gross birth defects to reductions in the ability of vertebrate immune systems to resist disease, to subtle impacts on adult sexual behavior, orientation, and morphology. Xeno contamination, for example, can disrupt the genetic specification of sex to such an extent that a gull whose genes spell MALE has functional ovaries. They can override the mechanism by which temperature normally determines the sex of turtle eggs. They feminize brain lateralization in sons of women who used DES during pregnancy. Imagining that some contaminant might likewise distort migration in a bird whose genes spell MIGRATE TO AFRICA thus enters the realm of the plausible.

Virtually any part of the development process that involves estrogens or androgens is potentially vulnerable to xeno-impact. And because these hormones are involved throughout development, you're safer to assume xenos can have an impact, than to ignore them.

And the holes in this hypothesis? We don't know whether xenos or their analogs interfere with migratory orientation. Decades have gone by since Rachel Carson first wrote about pesticides in *Silent Spring*, but the studies that would test for impacts on orientation have not been done.

What will resolve this dispute? First, we need more of the type of work that Berthold has pioneered, carried beyond the first generation and with appropriate crosses and backcrosses to eliminate all non-genetic mechanisms definitively. We also need work that can reveal when during development—and with what involvement by hormones—migratory orientation is translated from genes to behavior.

Simultaneously, we need research into what contaminants, including xenos, do to birds' migratory competency. From all that we know about xenos, it won't be enough to test an adult contaminated only after it had developed to maturity; with xenos, the adults are themselves often immune to dosages that then have profound effects on their offspring. Tests will have to look at what happens to the offspring of females that become contaminated prior to fertilization. In fact, work with xenos in rats now suggests multi-generational transfer of behavioral abnormalities...feed a rat mother contaminated food prior to pregnancy and her offspring and their offspring will have problems, even though the second and third generations are never directly exposed to the contaminant.

We like to imagine that when we go into the wilderness, we are in places where no man or woman has ever tread. Likewise, scientists investigating the natural world like to assume they are investigating just that, the natural world, unperturbed by human hands. Unfortunately, neither assumption is safe. Drink the water from the remotest reaches of the Rocky Mountains and you risk *Giardiasis.* Ignore the staggering fact that the world's ecosystem is contaminated by persistent, bioaccumulative chemicals, and you risk missing the truth.

—J P Myers is Director of the W Alton Jones Foundation