Monitoring Wild Birds for Exposure to Environmental Toxicants

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The health and integrity of ecosystems and wildlife populations are often determined by interactions between wildlife and people, with biological, sociological and economic factors determining the overall status of wildlife species in the environment. In addition to a basic esthetic liking of wildlife by the public, in recent years, eco-tourism has been much developed in many areas of the world, not only to closely observe wildlife, but also to ensure protection of habitats containing wildlife, and as a means of sustaining economic growth of peoples inhabiting near-pristine environments. Although humans are generally most attracted to large animals with strong anthropomorphic associations, the most widely-appreciated section of wildlife (second to that of domestic animals) is that of wild birds, mainly because they are abundant, easy to see in the daytime, often show beautiful coloring, have pleasant songs, and, similar to flowers, are indicative to the public of a healthy "wild" environment. Ensuring health and integrity of wild bird populations is a task performed mainly at the government level by ornithologists, ecologists, other scientists and wildlife managers, and is largely determined by laws protecting wild birds and preserving suitably large and uncontaminated environments.

Apart from habitat loss, bird populations are most endangered by exposure to diseases and toxicants. Diseases are natural in origin, and although they constitute a major cause of illness and death in wild birds, they are only rarely involved in massive morbidity, such as was seen when the West Nile virus was introduced into North America. In contrast, exposure to toxicants is due to the intervention of man in the environment, and toxicoses from intentionally applied pesticides have been documented as being abundant and serious world-wide. The causes of such toxicoses have been mainly spraying with cholinesterase-inhibiting insecticides and more recently, exposure to second-generation anticoagulant rodenticides. Exposure to pharmaceuticals used in farm animals may also harm wild birds, exemplified by the massive mortality in the diclonefac toxicosis of *Gyps* vultures in India. The role of many environmental contaminants in wild bird health has been less thoroughly documented, apart from studies on DDT/DDE, lead and mercury.

A biomonitoring project, DABSE (Database for Avian Blood Spot Examination) for exposure to toxicants and diseases, has been instigated with the goal of producing a database of reference values (the degree of exposure) as measured in whole blood (stored as dried blood spots) of healthy feral birds, to environmental contaminants and diseases that might harm the health of birds. Once these "normal" values have been determined, the diagnosis of possible ill-health (manifestations of illness, increased mortality, population reductions, lowered reproductive success, abnormal behavior) in a wild bird population, could be facilitated by comparing exposure parameters to reference values of the same species in the database; such data might reveal the cause and lead to a mitigating response. DABSE is based on determining whole blood concentrations of the 5 groups of environmental contaminants that are most examined in human biomonitoring projects and that are the most likely to harm birds over the long term, these groups of toxicants being elements, organochlorine pesticides, polychlorinated biphenyls, polybrominated biphenyl esters and perfluorinated compounds. Human biomonitoring assesses exposure to environmental toxicants by measuring the chemicals or their metabolites invariably in blood or urine. It is thought that subtle deleterious effects recently found in humans might be manifested in birds too, inducing difficult to discern changes in bird behaviour, reproduction and health. Blood is the optimal matrix for monitoring most environmental contaminants in birds as it is in contact with all tissues where chemicals are deposited and stored, reflects largely recent exposure, and sampling is relatively non-invasive and harmless if bleeding is conducted correctly. A major problem of avian biomonitoring is the considerable cost involved in the quantitative

analysis for these 5 groups of environmental contaminants and so for certain groups, representative markers, invariably found in birds' blood at the highest concentration of all the constituents in that group, are used; this use of markers lowers costs. The 5 groups are briefly detailed below (analytes are italicized), referring to proven and suspect human health effects and known findings in wild birds:

Elements. *Arsenic* – in man, increased arsenic exposure in drinking water has been associated with several cancers, toxic effects of the liver, skin, kidney and lung, increased mortality, and to deleteriously affect children's intelligence and growth. Measurement of arsenic exposure in birds has only rarely been carried out. *Cadmium* – human health risks from environmental exposure are manifested by kidney damage, increased stroke and heart failure prevalence, and perhaps hypertension. Only rarely has cadmium been examined in wild bird blood. *Lead* – a serious developmental neurotoxicant in children at blood levels below those seen in many birds, as well as delaying sexual development. Lead has also been found to be neurotoxic in birds, affecting growth, locomotion, balance, food begging, feeding, thermoregulation, and depth perception. It is an often-found and serious contaminant in birds, killing many thousands of birds yearly in the US. *Mercury* – methyl mercury in wild birds has been found to be neurotoxic, immunosuppressive, affects reproduction, and may disrupt endocrine systems of chicks, and has been shown to be one of the most harmful environmental contaminants in birds. *Selenium* – in man, severe deficiency is a major health problem. Excessive exposure in feral aquatic birds was associated with embryotoxicity, mortality, reduced growth, liver lesions and abnormal feather loss. High blood levels have been recorded as being normal in many seabird species and in such species selenium may have a role in mitigating exposure to mercury and other toxic elements.

Organochlorine pesticides. Although the most harmful of these pesticides have been almost entirely banned worldwide, *p,p'-DDT* is still used for indoor use in endemic vector and malaria control in some countries, and may be still used illegally, even in Europe. Exposure to its persistent metabolite, *p,p'-DDE*, caused severe and widespread eggshell thinning and poor reproductive success in high-trophic birds. The DDE to DDT ratio may indicate exposure to recent DDT use. β-*HCH* is the most persistent isomer of the hexachlorocyclohexanes, compounds once used as insecticides and fungicides; elevated blood levels were associated with a diagnosis of Parkinson's disease, and birds showing high blood levels may be afflicted with increased nest predation. *Hexachlorobenzene* (HCB) was used as a fungicide, and residues in wild birds have been associated with possible increased endocrinological stress and reduced immune function. *Oxychlordane* is the main and most persistent chlordane metabolite; in wild birds it may inhibit thyroid function and be immunosuppressive.

Polychlorinated biphenyls (PCBs). PCBs are chlorinated aromatic pollutants that are highly lipophilic and many congeners are persistent, bioaccumulative and biomagnified. Studies in humans after low environmental exposure have revealed subtle injurious effects on developmental toxicity, neuropsychology, hearing deficits, cardiovascular diseases, male reproduction, and blood testosterone levels. Such effects are obviously more difficult to discern in wild birds, but depressed productivity, decreases in blood thyroxine and deleterious effects on nesting behavior have been reported. The *PCB 153 congener* is used as the marker for exposure.

Polybrominated biphenyl esters (PBDEs). Congeners of the fire retardant group of PBDEs are persistent, bioaccumulative and biomagnified pollutants. Human health effects from PBDEs with low, ambient environmental exposures are largely unknown, and may include neurodevelopmental problems in children. In wild birds they are known to deleteriously affect reproduction and the immune response. The *PBDE 47 congener* is used as the marker for exposure.

Perfluorinated compounds (PFCs). PFCs are extraordinarily persistent environmental contaminants. Although extensively used for decades, adverse human health effects from PFCs at low environmental levels are unknown, although recent negative effects on human fecundity and fetal growth and an association with thyroid disease have been shown. Experimental data in fowl showed reduced hatchability and defects in prehatch and early posthatch development in chicks. The PFC markers in DABSE are the more persistent perfluoroalkyl acids, *perfluorooctane sulfonate* (PFOS) and *perfluorooctanoic acid* (PFOA).

Analytical methods have been developed to acheive low parts per billion quantification in just 200 µl of whole blood, such determinations being suitable for biomonitoring even small birds weighing less than 20 g. DABSE uses dried blood spots, which also have many advantages over normal blood sampling, storage and transportation, particularly for field studies of wild birds.

The overall object of DABSE is to document data on as many healthy wild bird species as possible, at least family representatives. An important aim of the project is directed towards investigating the possible effect of harmful agents in the demise of threatened or endangered species. The DABSE project will be further developed to screen for exposure to selected diseases and perhaps more acute acting toxicants. As DABSE has no inherent financial support, all analyses in the project will have to be funded by participation in sponsored research, or by researchers paying for the analyses.

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