What wild bird eggs tell us about persistent organic pollutants in South Africa?

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Introduction

Since the original release of Rachel Carson's book, Silent Spring in 1962, birds have been recognized as sentinel species for persistent organic pollutants (POPs). Birds are specifically sensitive to POPs. As birds inhabit almost every conceivable habitat and feeding niche, they make excellent indicators for the status of POPs within a specific environment. Birds not only indicate the presence of POPs, but through the investigation of distribution of pollutants within various species representing different habitats, they also indicate possible sources of these chemicals.

Bird eggs are considered good indicators of organohalogen compounds in the environment owing to their high lipid and protein content. Therefore, eggs as a matrix represent both the standard accumulation pattern associated with POPs in lipids, as well as the accumulation of perfluorinated compounds (PFCs) in proteins. During egg formation, pollutants are transferred from the female bird to her eggs, reflecting the body burden of the female bird indicating the level of these pollutants in the environment.

Since the early 2000s, numerous studies on the concentrations of POPs in birds' eggs collected in South Africa have been conducted [1,2,3,4,5,6]. These studies focused on numerous classes of POPs (polychlorinated biphenyls (PCBs), organochlorine pesticides (OCPs), PFCs, brominated flame retardants (BFRs), and dioxins). Here, we review the concentrations of POPs in wild bird eggs from South Africa. The contamination profile, species-specific differences, and the influence of different feeding guilds and habitat was investigated.

Materials and methods

The analyses of BFRs, OCPs, and PCBs were performed using gas chromatography mass spectrometry (GC-MS) and gas chromatography coupled to electron capture detectors (μ-ECD) at the Laboratory of Environmental Toxicology at the Department of Food Safety and Infection Biology, Norwegian University of Life Sciences, Norway. The laboratory is accredited by the Norwegian Accreditation for testing biological material of animal origin according the requirements of the NS-EN ISO/IEC 17025.

PFCs were analysed at the National Metrology Institute of South Africa (NMISA). Briefly, subsamples of homogenized eggs were extracted in duplicate with methanol, spiked with internal standard, and purified using dispersive solid phase extraction with activated carbon (EnviroCarb™). Thereafter, samples were concentrated, filtered, and analysed on an Agilent 1100 Series HPLC coupled to a Waters Micromass Quattro Micro electrospray ionization tandem MS, using a fluorinated reverse phase column. For a calibration curve to be used for quantification an R^2 greater than 0.99 had to be obtained. Blank matrix, method blank, and spiked matrix-matched recovery control samples were included with each batch to ensure the quality of the extraction and analytical runs.

Results and discussion

All of the bird eggs analysed had quantifiable levels of one or more of the POPs, irrespective of the species or the sampling location. As expected, the feeding guild and habitat of the wild birds had a statistically significant effect on the POPs concentrations (ANOVA; $p < 0.05$; Figures 1 and 2). OCPs and BFRs were more prevalent in species that were opportunistic feeders (termed generalist that utilized both the aquatic and terrestrial environment for feeding), whereas PFCs and PCBs were prevalent in piscivores.

It is generally expected that concentrations of more recently regulated POPs such as PFCs and BFRs will be higher than classic POPs such as PCBs and OCPs. This is the case in wild bird eggs from central and western South Africa. In these areas, PFCs had the highest concentrations, followed by OCPs, PCBs, and the lowest concentrations were for BFRs. However, this was not the case in areas where DDT is still used for malaria control. In these regions, OCPs are generally an order of magnitude higher that any of the other POPs measured. The highest concentrations measured for POPs in wild bird eggs were 20 000 ng/g wm for OCPs, followed by 2 900 ng/g wm for PFCs; 540 ng/g wm for PCBs; 220 ng/g wm for BFRs and 0.01 ng/g wm for dioxins.

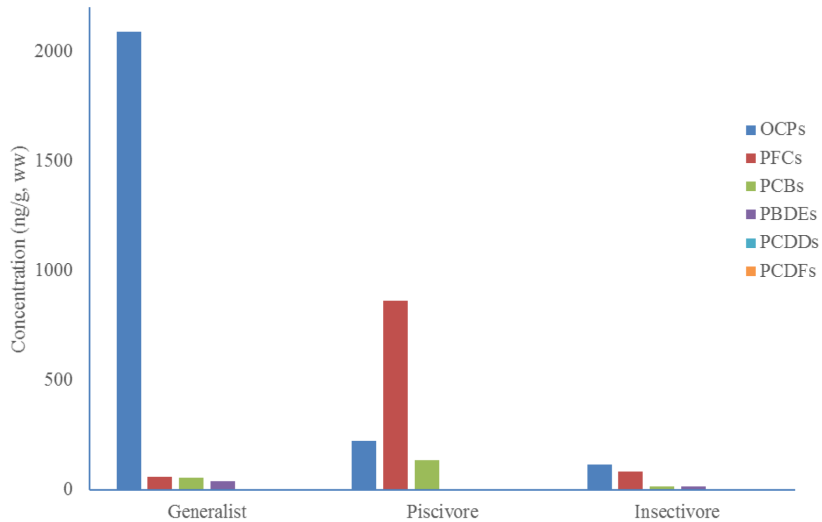

Figure 1: The distribution of POPs in eggs of wild birds from various feeding guilds

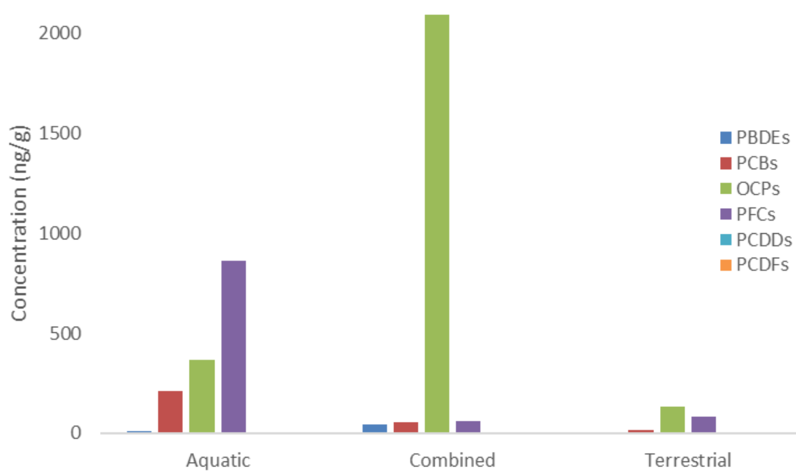

Figure 2: The distribution of POPs in wild bird eggs according to habitat use

As expected for higher trophic levels, PFCs and PCBs dominated in piscivore eggs. OCPs were higher in generalist eggs in areas where DDT is actively used for malaria control. Concentrations of BFRs were strongly influenced by the degree of association of the wild birds with humans: species (such as the Sacred Ibis) that feed on or close to human refuse dumps had the highest concentrations. High concentrations of PFCs in wild bird eggs are indicative of more recent exposure (as in the case of DDT), with these chemical classes being of highest concern within the South African environment.

The presence and variety of POPs in wild bird eggs indicate that these species are continually being exposed to a mixture of POPs. This signifies an environment impacted by anthropogenic activity. Even though the concentration of a specific compound may lie below the observable effects limit, the toxicity of the chemicals combined could negatively affect not only the bird species in these areas but also the environment as a whole and therefore human health.

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