Environment International 67 (2014) 12–21

Contents lists available at ScienceDirect

Environment International

journal homepage: www.elsevier.com/locate/envint

An overview of existing raptor contaminant monitoring activities in Europe

P. Gómez-Ramírez [a,*], R.F. Shore [b], N.W. van den Brink [c], B. van Hattum [d], J.O. Bustnes [e], G. Duke [f], C. Fritsch [g], A.J. García-Fernández [a], B.O. Helander [h], V. Jaspers [i,j], O. Krone [k], E. Martínez-López [a], R. Mateo [l], P. Movalli [d], C. Sonne [m]

[a] Department of Toxicology, Faculty of Veterinary Medicine, University of Murcia, Campus de Espinardo, 30100 Murcia, Spain
[b] NERC, Centre for Ecology and Hydrology, Lancaster Environment Centre, Library Avenue, Bailrigg, Lancaster LA1 4AP, UK
[c] Alterra, Wageningen UR, Box 47, NL-6700AA Wageningen, The Netherlands
[d] Institute for Environmental Studies, VU University, De Boelelaan 1087, 1081 HV Amsterdam, The Netherlands
[e] Norwegian Institute for Nature Research, FRAM—High North Research Centre on Climate and the Environment, NO-9296 Tromsø, Norway
[f] Environmental Change Institute, Oxford University Centre for the Environment, South Parks Road, Oxford OX1 3QY, UK
[g] Chrono-Environnement, UMR 6249, University of Franche-Comté -, CNRS, Usc INRA, Place Leclerc, F-25030 Besançon Cedex, France
[h] Swedish Museum of Natural History, Department of Contaminant Environmental Research & Monitoring, Box 50007, SE-104 05 Stockholm, Sweden
[i] Department of Biology, University of Antwerp, Universiteitsplein 1, 2610 Wilrijk, Belgium
[j] NTNU, Realfagbygget, DU2-169, Høgskoleringen 5, Trondheim 7491, Norway
[k] Leibniz Institute for Zoo and Wildlife Research, Alfred-Kowalke-Strasse 17, 10315 Berlin, Germany
[l] Instituto de Investigación en Recursos Cinegéticos (IREC), CSIC-UCLM-JCCM, Ronda de Toledo s/n, 13071 Ciudad Real, Spain
[m] Arctic Environment, Department of Bioscience, Aarhus University, Roskilde, Denmark

ARTICLE INFO

Article history:
Received 4 September 2013
Accepted 10 February 2014
Available online 13 March 2014

Keywords:
Contaminants
Biomonitoring
Raptors
Europe
Inventory

ABSTRACT

Biomonitoring using raptors as sentinels can provide early warning of the potential impacts of contaminants on humans and the environment and also a means of tracking the success of associated mitigation measures. Examples include detection of heavy metal-induced immune system impairment, PCB-induced altered reproductive impacts, and toxicity associated with lead in shot game. Authorisation of such releases and implementation of mitigation is now increasingly delivered through EU-wide directives but there is little established pan-European monitoring to quantify outcomes. We investigated the potential for EU-wide coordinated contaminant monitoring using raptors as sentinels. We did this using a questionnaire to ascertain the current scale of national activity across 44 European countries. According to this survey, there have been 52 different contaminant monitoring schemes with raptors over the last 50 years. There were active schemes in 15 (predominantly western European) countries and 23 schemes have been running for >20 years; most monitoring was conducted for >5 years. Legacy persistent organic compounds (specifically organochlorine insecticides and PCBs), and metals/metalloids were monitored in most of the 15 countries. Fungicides, flame retardants and anticoagulant rodenticides were also relatively frequently monitored (each in at least 6 countries). Common buzzard (*Buteo buteo*), common kestrel (*Falco tinnunculus*), golden eagle (*Aquila chrysaetos*), white-tailed sea eagle (*Haliaeetus albicilla*), peregrine falcon (*Falco peregrinus*), tawny owl (*Strix aluco*) and barn owl (*Tyto alba*) were most commonly monitored (each in 6–10 countries). Feathers and eggs were most widely analysed although many schemes also analysed body tissues. Our study reveals an existing capability across multiple European countries for contaminant monitoring using raptors. However, coordination between existing schemes and expansion of monitoring into Eastern Europe is needed. This would enable assessment of the appropriateness of the EU-regulation of substances that are hazardous to humans and the environment, the effectiveness of EU level mitigation policies, and identify pan-European spatial and temporal trends in current and emerging contaminants of concern.

1. Introduction

Biomonitoring studies using wildlife can provide an important source of information for understanding the potentially harmful effects of environmental contaminants, both in ecological receptors and in humans (Woodruff, 2011). Examples where similar detrimental effects

* Corresponding author. Tel.: +34 868887021; fax: +34 868884147.
E-mail address: pilargomez@um.es (P. Gómez-Ramírez).

http://dx.doi.org/10.1016/j.envint.2014.02.004

have been observed both in wildlife species and in humans include immune system impairment in black kites (*Milvus migrans*) (Blanco et al., 2004) and children (Lutz et al., 1999) due to exposure to cadmium or lead, and PCB-induced altered reproductive behaviour in glaucous gulls (*Larus hyperboreus*) (Bustnes et al., 2001) and neurological effects in children (Jacobson et al., 1990). Biomonitoring in wildlife, in fact, can serve as an early warning or sentinel of potential impacts in humans. For example, research on lead intoxication in white-tailed sea eagles (*Haliaeetus albicilla*) (Helander et al., 2009; Krone et al., 2003, 2009; Nadjafzadeh et al., 2013) highlighted the health risks for raptors and humans from consuming game meat in Germany and Sweden (Federal Institute for Risk Assessment Germany, 2011; Kneubuehl, 2011; NFA, 2012). Studies on lead intoxication in red kites (*Milvus milvus*) (Pain et al., 2007) highlighted similar risks in the UK which have subsequently been realised for people (Green and Pain, 2012; Pain et al., 2010).

The European Union (EU) has developed a range of policies and legislative instruments to address environmental contamination (Duke, 2008). This includes the relatively recent REACH directive (European Commission, 2006) and policies on persistent organic pollutants (European Commission, 2004, 2007), pesticides and biocides (European Commission, 2012). These instruments operate at an EU-wide scale to protect human health and the environment. A key issue with all such legislative instruments is to determine how effective they are. Measuring the numbers of registrations, authorisations and restrictions on chemicals only provides data on activities undertaken under the auspices of the EU directives. Such measures do not provide information on how effective the measures were in achieving mitigation targets—that requires monitoring. Direct monitoring of air, soil, water and sediments can be useful for determining the degree of contamination in a particular area, but does not provide a measure of bioavailability and resultant uptake by biota or people. It is only through direct biomonitoring (the analysis of contaminants in tissues of organisms) that the actual exposure of organisms can be properly determined and related to levels in the physical environment (Schubert, 1985). Furthermore, when biomonitoring is also designed to examine effects, new data are obtained on the possible detrimental effects of compounds on a range of species, including sensitive species and humans (García-Fernández and María-Mojica, 2000; NRC, 1991).

Biomonitoring is often carried out using proven sentinels of environmental contamination. The value of birds as biomonitors of environmental pollution has been broadly recognised (Grasman et al., 1998; Newton et al., 1993; Rattner, 2009; van Wyk et al., 2001). This is also evident from the establishment of several governmental monitoring programmes, such as the Trilateral Monitoring and Assessment Programme, the National Swedish Contaminant Monitoring Programme (Becker, 2003) and the Arctic Monitoring and Assessment Programme (AMAP). Amongst birds, raptors (birds of prey, owls and scavengers) are considered especially suitable for monitoring PBT (persistent, bioaccumulative, toxic) chemicals (e.g. Sergio et al., 2005, 2006), although the choice of species and associated traits (such as foraging in terrestrial or freshwater habitats) need to be matched to the fate pathways of the compounds of interest. There are a number of key characteristics that make raptors good sentinels for environmental contaminants. These include: position in food webs (often apex predators), relatively long lifespan over which to accumulate contaminants, integration of exposure both over time (Furness, 1993) and relatively large spatial areas, relative ease with which individuals (particularly nestlings) can be captured and non-destructive samples (blood, feather, preen gland oil) collected, and relative ease with which populations can be quantified and monitored. These criteria are all identified by the U.S. National Research Council as requirements for sentinel species (NRC, 1991). Raptors are also known to have measurable responses to PBT chemicals, ranging from residue accumulation to population decline. Indeed, it was the dramatic population declines observed in the bald eagle (*Haliaeetus leucocephalus*) in the basin of the Great Lakes in North America USA (Bowerman et al., 1995), the peregrine falcon (*Falco peregrinus*), eurasian sparrowhawk (*Accipiter nisus*) and golden eagle (*Aquila chrysaetos*) in the UK (Ratcliffe, 1970) and the white-tailed sea eagle in Sweden (Helander et al., 2008) that sparked awareness for the need to control the environmental release of several organochlorine compounds. This clearly demonstrated the value of raptors as powerful sentinels for environmental monitoring (Helander et al., 2008). In fact, the current ban under the Stockholm Convention on PCBs and other PBT compounds that are potentially harmful to both people and wildlife has been partly based on exposure and effects data in raptors (Rattner, 2009).

In Europe, there is a large number of biomonitoring programmes using raptors. However, only some are established at a national scale. They include the National Environment Monitoring Programme in Sweden (Helander et al., 2008), the Predatory Bird Monitoring Scheme (PBMS) in the United Kingdom (Walker et al., 2008), the Bird Monitoring Programme in Finland (Koskimies, 1989) and the Monitoring Programme for Terrestrial Ecosystems (TOV) in Norway (Gjershaug et al., 2008). However, these schemes are not linked, and so do not identify trends in contamination at the broader (European) spatial scale. Published papers and reports provide evidence that contaminant studies using raptors are also conducted in other EU countries, such as Spain, Germany, Belgium, Italy and The Netherlands (Gómez-Ramírez et al., 2011; Jaspers et al., 2006; Kenntner et al., 2003; Movalli et al., 2008b; van den Brink et al., 2003). However, these studies are typically limited in spatial extent and/or duration and are rarely repeated (García-Fernández et al., 2008). Overall therefore, there appears to be widespread capability and expertise to use raptors to monitor the effectiveness of EU directives at a pan-European scale. However, existing national and sub-national monitoring initiatives need to be reinforced and coordination at a pan-European scale improved (Movalli et al., 2008a).

The first requirement to assess the potential for EU-wide coordinated monitoring with raptors is the knowledge of the current scale of ongoing monitoring activities. Indeed, it is possible that monitoring of some contaminants may already be sufficiently widespread to allow assessment of temporal and spatial trends at an EU scale. However, whether this is, in fact, the case is unknown because there is no EU-wide inventory of monitoring activity. For this reason, the aim of the present manuscript was to investigate the possibility of EU wide monitoring using raptors. This was done both by means of a questionnaire designed to elucidate current contaminant monitoring activities with raptors across Europe and by interpretation of the results during a workshop by relevant members of EURAPMON (Research and Monitoring for and with Raptors in Europe; http://www.eurapmon.net), a European Science Foundation Research Network.

2. Material and methods

A questionnaire template was designed based on the existing questionnaire used by the WILDCOMS network in the UK (http://www.wildcoms.org.uk/). This comprised an Excel document (Microsoft Office 2007) with questions gathered in five worksheets (Table S1 in Supplementary material). The majority of questions were closed in nature, since they provide a greater uniformity of responses and are more easily processed than open-ended questions, where the respondent provides free text answers (Babbie, 2013). The first worksheet contained questions regarding the metadata of the scheme, for instance the name of scheme or project, the year it started, the duration and the species monitored. In the subsequent worksheets, the questions focused on the main aims of the monitoring projects, the type of samples collected, types of contaminants determined, and how the results of the projects were disseminated.

A mailing list of 62 researchers engaged in biomonitoring environmental pollutants with raptors in Europe was compiled using a contact database established by EURAPMON, or by directly contacting researchers identified from their peer-reviewed research articles or internet sites. Additionally, 134 other researchers identified through the EURAPMON network as potentially working on monitoring of contaminants with raptors were contacted by e-mail to inform them about the questionnaire and requesting that they provide contact details for