Research Networking Programmes

Short Visit Grant ☐ or Exchange Visit Grant ☒

(please tick the relevant box)

Scientific Report

The scientific report (WORD or PDF file – maximum of eight A4 pages) should be submitted online within one month of the event. It will be published on the ESF website.

***Proposal Title**:* A pan-European assessment of exposure to and the associated health impact of major contaminants in European raptor species and their subpopulations

Application Reference N°: 4895

1) Purpose of the visit

Certain chemical compounds, such as mercury (Hg) and polychlorinated biphenyls (PCBs), are widely attributed with toxic effects on wildlife and humans. Moreover, their bioaccumulation is of a continuing nature due to ongoing leaching and persistent residence in the environment, even after the production and use of some has been (partly) legalized. Therefore, contaminant monitoring is highly necessary both for and with raptors, the latter especially in the sense that raptors are excellent early-warning systems for human health (Burger and Gochfeld 2001).

Such a raptor monitoring scheme needs to maintain a pan-European scope as the exposure of both raptor, e.g. White-tailed Eagle Haliaeetus albicilla and Osprey Pandion haliaetus (Kalisinska et al. 2014), and songbird species, e.g. Great Tit Parus Major, Blue Tit Cyanistes caeruleus and European Starling Sturnus vulgaris (Eens et al. 2014; Van den Steen et al. 2009, 2010), have shown to be highly variable among different European subpopulations. However, the lack of international research prioritization and cooperation, as well as the absence of harmonization of best practices and skills, are reasons why to present day pan-European contaminant monitoring for and with raptors has not yet been endeavored.

Nonetheless, its logistical feasibility has been suggested to exist as already 52 different contaminant monitoring schemes have been carried out using different species throughout Europe (Gomez-Ramirez et al. 2014). Moreover, a core-group of European specialists is

in the progress of publishing best practices in contaminant monitoring using raptors (Espin et al. in preparation), and has already provided a summary protocol in open access on the EURAPMON website. These outcomes from earlier EURAPMON exchange visits have as such succeeded in providing the first steps towards pan-European contaminant monitoring.

The very purpose of this exchange visit is to employ scientific literature to not only further show the high necessity for pan-European contaminant monitoring, but also to identify and prioritize species, and their subpopulations, and sampling methods that are logistically feasible, methodologically valuable, and of toxicological concern. Lastly, such empirical evidence will practically promote pan-European networking and collaboration of researchers working both for and with raptors, and provide as such a scientific and networking basis on which a first ever pan-European contaminant monitoring scheme for and with raptors can be built.

2) Description of the work carried out during the visit

An initial imitative to create pan-European assessments of exposure to and the associated health impact of major contaminants in European raptor species and their subpopulations is the collection of peer-reviewed scientific literature. Given the suspected large amount of available literature on several major environmental contaminants of interest, a.o. but not restricted to Hg, polychlorinated biphenyls, organochlorine pesticides, flame retardants, and poly- and perfluoroalkylated substances, as well as European raptor species, the scope of the exchange visit was prioritized to create a (first ever) pan-European assessment that focusses on the high exposure contaminant Hg, and if time permits on a second high volume contaminant, i.e. PCBs, in 12 species shown to be commonly monitored in Europe, i.e. Barn Owl Tyto alba, Common Buzzard Buteo buteo, Common Kestrel Falco tinnunculus, Eurasian Eagle-owl Bubo bubo, Eurasian Sparrowhawk Accipiter nisus, Golden Eagle Aquila chrysaetos, Long-eared Owl Asio otus, Northern Goshawk Accipiter gentilis, Osprey Pandion haliaetus, Peregrine Falcon Falco peregrinus, Tawny Owl Strix aluco, and White-tailed Eagle Haliaeetus albicilla (Gomez-Ramirez et al. 2014). With that scope, two large and well-known online databases, i.e. Thomson-Reuters' Web of Science and the National Centre for Biotechnology Information's PubMed database, were queried for relevant publications up to Feb 27 2015. The relevant publications were managed in an EndNote database, systematically ordered per species and contaminant.

A second initiative compiled two Microsoft Access databases using the collected literature: one on the exposure to Hg and one on its toxicological effects in European raptors. Although the literature necessary for a PCB assessment has been collected as well, further efforts were prioritized for Hg in order to ascertain presentable deliveries within the exchange visit time frame. The exposure database was designed as such to target country-specific (approximating subpopulation concept) exposure, when possible also individual data was logged, on accumulated concentrations of Hg (total, inorganic and organic Hg species) in a wide variety of matrices. Alongside the exposure data, metadata on age, sex, diet, location, habitat, year (or time period), season, and sampling and analysis conditions were collected as well. The effect database compiled information on reported species- and matrix-specific toxic threshold concentrations, as well as ranges of observed adverse effects on reproduction and survival to evaluate the reported effect

thresholds. Within the same database, Selenium (Se) accumulation was recorded as well because it impedes Hg toxicity through ligand binding. In addition to these two databases, a smaller database on reported country-specific legal restrictions on the use of Hg compounds was compiled.

A third initiative harmonized and analyzed the exposure and effect databases. Harmonization was deemed necessary as not only the statistical reporting from the extracted data was highly variable, but moreover the interpretation of actual data was confounded by the analysis of fresh versus dried matrices, the analysis for different Hg species, the lack of reporting annual concentrations (rather most often entire periods), sampling of different ages and sexes. Using the harmonized database, we employed data management operators in the programme language R as well as the Geographical Information System ArcGis to prepare the data for an assessment that was visually informative, rather than using hard-core statistical analysis. The latter one would have required further harmonization of data, e.g. extrapolating between matrices and time periods which, after consultation of an experienced trend statistician, was deemed unfavorable as it would have only introduced a high amount of uncertainty into the resulting outcomes. As such, we analyzed how concentrations in different species, and their subpopulations, relate to toxic thresholds on reproduction and survival, during different periods of agricultural Hg compound use, i.e. prior, during and after legal restrictions.

A fourth initiative started the creation of a scientific manuscript (see below for projected publication #2). The manuscript is currently being written, and reviewed by co-authors of the host institution. The manuscript does not only present the above-outlined pan-European assessment (see below under 'description of the main results'), framed as well in a worldwide geographical context, but provides in addition concepts and good practice recommendations for a pan-European Hg monitoring scheme for exposure an effects in raptors, e.g. species and matrices to prioritize, how to minimize confounding by biological, temporal and spatial factors.

A last initiative aimed at employing the compiled empirical evidence to show the necessity and feasibility of pan-European contaminant monitoring for and with raptors. To this end, the main results have been incorporated in a poster and a 20 minutes oral presentation, both presented and complimented at the final EURAPMON conference held shortly after the exchange visit at Aledo, Spain (8-11 Mar 2015). These presentations will be made open access available through the EURAPMON website. The oral presentation was given during a workshop aimed at starting a first ever pan-European contaminant monitoring scheme, which I co-chaired with Richard Shore (University of Manchester, United Kingdom) and prepared during the last weeks of my exchange visit.

3) Description of the main results obtained

The literature search resulted in data for all 12 targeted species, and resulted as such in 81 publications on Hg exposure in European subpopulations, 45 publications on extra-European subpopulations, 29 publications on Hg health effects in raptor species, and 114 publications for PCB exposure in European subpopulations. By reviewing these publications for he targeted 12 species, exposure data was also found for 21 additional

species, and subsequently also compiled in the Microsoft Access exposure database. The compiled exposure and effect databases, together with the four-entry 'legal Hg restrictions' database will be made available on the EURAPMON website for registered members.

The poster and oral presentation available through the EURAPMON website show the geographical European extent for which Hg exposure data is available for the targeted 12 species (classified according to their dietary preferences). It is clear from the figure that monitoring efforts have been primarily focused on western-Europe (the red color indicating countries with no recorded studies on Hg exposure in raptors), and the majority has been contributed by northern countries. Certain species, such as Common Buzzard, Eurasian Sparrowhawk, Tawny Owl, show a wide geographical coverage and appear to be feasible for future pan-European monitoring schemes. Nonetheless, it is clear that most studies have been performed on piscivorous species, likely from a toxicological concern (see also figure with European map), which seem however to be geographically restricted to northern regions. When considering the different matrices used to quantify Hg accumulation, feathers (43%) and liver (38%) were the most frequently analyzed, closely followed by kidney (34%), egg (21%) and muscle (21%). Given these numbers, we choose to assess hepatic Hg concentrations, as well Hg quantified in matrices that seem to be analytically feasible while relatively easy to collect non-destructively, i.e. eggs and feathers (figures are can be obtained from the poster and oral presentations available through the EURAPMON website.

Exposure data reported for all three matrices show that the highest concentrations are found in northern countries, a.o. Norway, Sweden, Finland, as well as in Germany, Poland and the United Kingdom. These are indeed countries for which intensive use of organic Hg compounds for agricultural purposes has been recorded. In fact, these are also the sole countries for which the literature review resulted in specific dates on which such use was legally banned, while such information is lacking, or perhaps simply not applicable for other European countries. It is also clear that thresholds for reproductive impairment and mortality were most often reached or surpassed in avivorous and piscivorous species, while the health risks for mammivorous species is considerably lower. When returning to the suitability of the different matrices, feathers seemed most valuable as they were the sole matrix allowing for temporal assessments of the impact of anthropogenic Hg usage, e.g. from agricultural applications. This assessment based upon feather concentrations shows as such that recorded national restrictions on the use of organic Hg compounds resulted in reduced exposure, which however has to present day not yet returned to assumed natural background levels. Certain observations of exposure surpassing threshold levels seem to indicate that even in recent times some subpopulations may suffer sublethal stress of Hg exposure, which may in fact synergistically interact with stress experienced from other contaminants or changing habitat and climate conditions.

As announced above ('under description of the work carried out'), the manuscript that is currently being written down addresses concepts and good practice recommendations for a pan-European Hg monitoring scheme. While these are an elaborate part of the manuscript, reviewing individual studies on reported confounding biological and spatial factors, we can highlight in this report that future schemes are likely to greatly benefit from sampling nestlings as confounding from various biological and spatial confounding

variables is greatly minimized at this life stage. Then again, from a toxicological perspective, it is certainly valuable to collect carcasses from juvenile birds, as these cannot sequester Hg through molting feathers (which are reported to contain up to 80% of the total Hg body burden). From the available data, we however also need to conclude that the confounding impact from all imaginable biological factors is not fully elucidated, and that e.g. further species-specific investigations on sex and age-related accumulation are required.

4) Future collaboration with host institution (if applicable)

The host institution has agreed to employ the applicant of this exchange visit (Igor Eulaers) in a post-doctoral researcher function, which will allow him to carry forward the research and networking momentum that he has created during his exchange visit. This will not only allow for fast publication of the projected publications (see below under 'projected publications'), but will also put the host institution in a central position in future collaborations sprouting from the initiatives taken during this exchange visit. Amongst such collaborations will be future literature-based pan-European assessments for major contaminants other than Hg and PCBs (see below under 'other comments'), and, more importantly, the host institution will be one of two central players (together with the University of Manchester) in future collaborations on the development and coordination of future pan-European contaminant monitoring schemes for and with raptors. This initiative and leadership has been warmly supported by several researchers during the workshop on pan-European contaminant monitoring, held at the final EURAPMON conference, and has been voted to be a major constituent in upcoming project proposals for the future continuation of EURAPMON activities.

5)* Projected publications / articles resulting or to result from the grant *(ESF must be acknowledged in publications resulting from the grantee's work in relation with the grant)

Based upon the work that was carried out during the exchange visit, as well as the momentum it created, we foresee at least three publications during 2015:

1. Eulaers et al. A pan-European assessment of contaminant exposure and associated health effects in European raptor species and their subpopulations. Part 1: Mercury. To be submitted to Environment International (impact factor 5.664).

2. Eulaers et al. A pan-European assessment of contaminant exposure and associated health effects in European raptor species and their subpopulations. Part 2: Polychlorinated biphenyls. To be submitted to Environment International (impact factor 5.664).

3. Eulaers et al. Necessity, feasibility and concepts for pan-European contaminant monitoring for and with raptors. To be submitted to Ambio (impact factor 2.973) as part of a special issue dedicated to EURAPMON.

The first publication is currently being written and reviewed, and will be published within a short time frame. The second one is in preparation, as the literature has been compiled but still requires analysis and reporting. It will however also be published within half a

year as it can build upon the template provided by the first publication. However, as the composition of similar assessments on other major contaminants are under discussion (see below under 'other comments'), we might consider a special issue on pan-European assessments in a specialized journal if such timing does not significantly delay the just-mentioned time frames for the publications resulting from this exchange visit. The third projected publication will built upon the conclusions of the first two publications (and possibly similar ones) and will therefore be published later during 2015, alongside a suite of publications in a special issue dedicated to EURAPMON. The arrangement of such special issue is already being negotiated with editors from several scientific journals.

Finally, the co-authorship for the above-mentioned projected publications has not yet been specified into detail. In general agreement, however, the first two projected publications will be co-authored by raptor specialists at the host institution that contributed to the exchange visit, i.e. Christian Sonne, Rune Dietz and David Boertmann, by the co-organizer of the above-mentioned workshop on pan-European monitoring, i.e. Richard Shore, and by EURAPMON participants that are specialists in the use of raptors for monitoring the respective contaminants. The third projected publication will be co-authored by members of a core-group (currently still open for applications) that will join efforts in starting up a harmonized pan-European contaminant monitoring scheme using raptors. These members have recently indicated their interest in doing so at the workshop on pan-European contaminant monitoring held at the final EURAPMON conference.

6) Other comments (if any)

The conducted work during this research visit has shown that the compilation and harmonization of databases required for pan-European contaminant assessments, is more time-intensive as was initially expected. As mentioned-earlier (see above under 'description of the work carried out'), this is entirely due to the lack of any harmonized way of collecting and reporting exposure data in a high amount of available publications. For this reason, a multitude of assessments on different major contaminants can complement the projected two publications on Hg and PCBs, but are impossible to be performed by a single researcher. Their execution is therefore currently being planned with relevant specialists, to appear ideally over the next coming year. These forthcoming publications will all benefit from the initial effort created during this exchange visit and we are therefore gracefully thankful to ESF for allowing us to create a significant research and networking momentum in the raptor contaminant monitoring community with this exchange visit.

Finally, we provide full references to the citations provided above:

Burger J, Gochfeld, M 2001. On developing bioindicators for human and ecological health. Environmental Monitoring and Assessment 66: 23-46

Eens M, Jaspers VLB, Van den Steen E, Bateson M, Carere C, Clergeau P, Costantini D, Dolenec Z, Elliott JE, Flux J, Gwinner H, Halbrook RS, Heeb P, Mazgajski TD, Moksnes A, Polo V, Soler JJ, Sinclair R, Veiga JP, Williams TD, Covaci A, Pinxten R. 2013. Can starling eggs be useful as a biomonitoring tool to study organohalogenated contaminants on a worldwide scale? Environment International 51: 141-149

Espin S, Garcia-Fernandez AJ, Herzke D, Shore R, van Hattum B, Martinez-Lopez E, Coeurdassier M, Eulaers I, Fritsch C, Gomez-Ramirez P, Jaspers VLB, Krone O, Duke G, Helander B, Mateo R, Movalli P, Sonne C, van den Brink NW. Best practices for pollutant exposure monitoring or raptors. In preparation

Gomez-Ramirez P, Shore RF, van den Brink NW, van Hattum B, Bustnes JO, Duke G, Fritsch C, Garcia-Fernandez AJ, Helander BO, Jaspers VLB, Krone O, Martinez-Lopez E, Mateo R, Movalli P, Sonne C. 2014. An overview of existing raptor contaminant monitoring activities in Europe. Environment International 67: 12-21

Kalisinska E, Gorecki J, Lanocha N, Okonska A, Melgarejo J, Budis H, Rzad I, Golas J. 2014. Total and methylmercury in soft tissues of White-Tailed Eagle (Haliaeetus albicilla) and Osprey (Pandion haliaetus) collected in Poland. Ambio 43: 858-870

Van den Steen E, Pinxten R, Covaci A, Carere C, Eeva T, Heeb P, Kempenaers B, Lifjeld JT, Massa B, Norte AC, Orell M, Sanz JJ, Senar JC, Sorace A, Eens M. 2010. The use of Blue Tit eggs as a biomonitoring tool for organohalogenated pollutants in the European environment. Science of the Total Environment 408: 1451-1457

Van den Steen E, Pinxten R, Jaspers VLB, Covaci A, Barba E, Carere C, Cichon M, Dubiec A, Eeva T, Heeb P, Kempenaers B, Lifjeld JT, Lubjuhn T, Mand R, Massa B, Nilsson J-A, Norte AC, Orell M, Podzemny P, Sanz JJ, Senar JC, Soler JJ, Sorace A, Torok J, Visser ME, Winkel W, Eens M. 2009. Brominated flame retardants and organochlorines in the European environment using Great Tit eggs as a biomonitoring tool. Environment International 35: 310-317