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PROGRESS ON BRINGING TOGETHER RAPTOR COLLECTIONS IN EUROPE FOR CONTAMINANT RESEARCH AND MONITORING IN RELATION TO CHEMICALS REGULATION

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Abstract:	<p>Movalli et al (2017) argued for development of a framework bringing together raptor tissue collections in Europe in support of contaminant monitoring for better chemicals management. We outline recent progress in this regard under the COST Action 'European Raptor Biomonitoring Facility' (ERBFacility). A review of 116 collections reveals that many thousands of raptor specimens arrive annually. In most countries, the main recipients are natural history museums, many of which store frozen samples suitable for contaminant monitoring. There is strong interest among collections to collaborate and enhance this tissue resource through development of a 'distributed European Raptor Specimen Bank'. Developing the Bank will involve: prioritising species, tissue matrices and compounds; proof of concept work; addressing legal and other constraints; enhancing standards and protocols for gathering, processing and storing samples; developing policy on access to samples; and developing a samples database. The Bank will be integrated with a complementary Biomonitoring Scheme (specifying priority contaminant analyses) and Sampling Programme (enhancing specimen supply). The resulting European Raptor Biomonitoring Facility will be capable of delivering pan-European contaminant data for chemicals management. Simultaneously, the project LIFE APEX is demonstrating systematic use of contaminant data from raptors (and other apex predators) for chemicals management. Applications include prioritization of substances for PBT assessments, identifying predominant chemical mixtures in biota, and assessing the effectiveness of EU chemicals risk management measures. Together, ERBFacility and LIFE APEX offer considerable promise to reduce contaminant risks to human and wildlife health in Europe.</p>	
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PROGRESS ON BRINGING TOGETHER RAPTOR COLLECTIONS IN EUROPE FOR CONTAMINANT RESEARCH AND MONITORING IN RELATION TO CHEMICALS REGULATION

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15 Environmental contaminants impose multi-billion Euro costs on human and
16 wildlife health in Europe (Trasande *et al* 2015). Although there are more than
17 60,000 chemicals marketed in Europe, so far only 600 chemicals have been
18 screened and identified as PBT (persistent, bioaccumulative, toxic), ED
19 (endocrine disrupting) and/or CMR (carcinogenic, mutagenic, toxic for
20 reproduction) (Gkotsis *et al* 2019). A suite of EU chemicals legislation (EC 2001,
21 EC 2004a, EC 2004b, EC 2004c, EC 2006, EC 2008, EC 2009a, EC 2009b, EC 2012)
22 aims to reduce chemical risks to humans and wildlife, and the EU's Seventh
23 Environment Action Programme (EC 2014) calls for better scientific knowledge
24 towards achieving a non-toxic environment.
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27 Movalli *et al* (2017) noted the value of raptors as sentinels of environmental
28 health in general, and highlighted in particular the potential value of raptor
29 tissue collections, which can be analysed for contaminant exposure to inform
30 risk assessment of chemicals, assess the effectiveness of chemicals risk
31 management measures, and provide early warning of emerging contaminant
32 problems. They argued for development of a framework bringing together raptor
33 tissue collections in Europe – including those of natural history museums
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1 (NHMs), environmental specimen banks (ESBs) and others (e.g. in research
2 institutions) – in support of contaminant research and monitoring for better
3 chemicals management. They suggested this framework would involve among
4 other things identifying and digitising relevant collections and developing a
5 searchable database of these collections to make them more visible and
6 accessible to ecotoxicologists and competent authorities.

7
8 Here, we outline progress that has been made in this regard through the launch
9 of two mutually reinforcing initiatives, the COST Action *European Raptor*
10 *Biomonitoring Facility*' (ERBFacility⁴¹), which launched in October 2017 and in
11 which 27 COST member countries are participating, and the EU LIFE project
12 *Systematic use of contaminant data from apex predators and their prey in*
13 *chemicals management* (LIFE APEX⁴²), which launched in September 2018.

14
15 Using raptors as particularly appropriate sentinels for PBT compounds (Movalli
16 *et al* 2018), ERBFacility will help answer what the environmental risks are for
17 specific chemicals, whether there are emerging contaminant problems needing
18 remedial action and whether legislation is at all effective in reducing
19 environmental exposure to contaminants in Europe. ERBFacility builds on ten
20 years of work involving ecotoxicologists and ornithologists leading up to and
21 under the European Science Foundation's research networking programme
22 EURAPMON (Research and Monitoring for and with Raptors in Europe) (see, for
23 example, Movalli *et al* 2008, Gómez-Ramírez *et al* 2015, Espín *et al* 2016, Derlink
24 *et al* 2018, Duke *et al* 2018).⁴³

25
26 At its first General Meeting in Ciudad Real, Spain in February 2018, ERBFacility
27 set in motion work to bring together NHMs, ESBs and other research collections
28 towards development of a European Raptor Specimen Bank (ERSpeB).
29 ERBFacility has since concluded a review of raptor collections in Europe
30 (Ramello *et al* in prep). The review, which collated data from over a hundred
31 collections across Europe, revealed that many thousands of raptor specimens
32 arrive annually at these collections, offering a very substantial resource of raptor
33 tissue samples for contaminant monitoring. In the UK, specimens are processed
34 and tissues stored by the Predatory Bird Monitoring Scheme maintained by the
35 Centre for Ecology and Hydrology (Walker *et al* 2008). In Sweden the lead is
36 taken by the national ESB at the Naturhistoriska Riksmuseet. A number of
37 research collections also exist around Europe, such as that of the Leibniz-
38 Institute for Zoo and Wildlife Research, Germany. However, such specimen banks
39 and research collections, set up specifically for the purposes of contaminant
40 monitoring, are the exception rather than the rule. In most countries, the main
41 recipients of raptor specimens are NHMs. Indeed, the review found that around
42 75% of responding NHMs across Europe receive fresh raptor/owl specimens.
43 Most NHMs freeze raptor carcasses on arrival and then process and freeze wet
44 tissues; indeed, around a third of responding NHMs are already active in storing
45 frozen raptor tissue samples suitable for contaminant monitoring.

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⁴¹ www.erbfacility.eu

59 ⁴² www.lifeapex.eu

60 ⁴³ www.eurapmon.eu

1 At a recent ERBFacility meeting convened at the Royal Belgian Institute of
2 Natural Sciences in Brussels, collections came together to validate the review of
3 raptor collections and consider how to build on this towards development of the
4 European Raptor Specimen Bank. The meeting found that there is strong interest
5 among collections to work together in this regard. However, many collections,
6 particularly in eastern and southern Europe, are stretched for resources, so any
7 new 'ask' (e.g. in terms of expanding tissue collections and/or strengthening
8 standard operating procedures to ensure sample quality) must be tightly
9 specified. Moreover, collections cannot be expected to build a substantial raptor
10 tissue bank unless there is a clear regulatory demand for contaminant data and
11 resources for the necessary analyses to be performed.
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14 There exists here something of a Catch 22, in that regulatory demand is likely to
15 grow only once the ability of raptor biomonitoring to provide pan-European
16 assessments pertinent to chemicals management is proven, while proving this
17 ability requires a substantial sample bank to be available in the first place.
18 Overcoming this will probably involve carefully targeted proof of concept work
19 on one or two selected species and tissue matrices for which a substantial pan-
20 European bank of samples already exists, and for one or two priority substances
21 of particular interest to regulators.
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24 There are clear incentives for collections to engage in this work. These include:
25 the opportunity to engage in a major European initiative with key regulatory
26 applications, helping to demonstrate the societal relevance of collections; the
27 opportunity presented by novel collaboration between NHMs, ESBs and research
28 collections; the opportunity to expand research interests into ecotoxicology, and
29 to expand publications output; and the opportunity to know of and exchange
30 samples with other NHMs and thereby broaden individual collections.
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33 Taking forward the concept of a distributed ERSpeB will involve further work
34 under the auspices of the COST Action on a number of issues, building on
35 relevant existing networks such as the Consortium of European Taxonomic
36 Facilities and the network of European Bird Curators. These include: prioritising
37 species, tissue matrices and compounds and carrying out proof of concept work;
38 addressing legal, personnel and freezer constraints to expanding raptor tissue
39 sample collections and shipping samples for analysis; adapting NHM standards
40 and protocols (learning from ESBs) for the gathering, processing and storage of
41 samples, to enhance sample quality for contaminant analysis; developing
42 appropriate policy on access to samples to ensure valuable samples required for
43 contaminant monitoring are not consumed for other purposes; circumscribing
44 the data content of the European samples database and how it will be developed,
45 populated and updated to provide real-time information on raptor tissue
46 samples across Europe. These issues will all be addressed by a sequence of
47 scientific missions and meetings planned by ERBFacility for the next 12-15
48 months.
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54 This paper focuses on work being done in the 'collections arena' under the
55 auspices of ERBFacility, but it is worth noting that ERBFacility also involves
56 work in the 'analytical arena', involving ecotoxicologists, veterinary scientists
57 and chemists, to develop a prioritized European Raptor Biomonitoring Scheme
58 (ERBiomS), and work in the 'field arena' involving field ornithologists and
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1 ecologists, to develop a European Raptor Sampling Programme (ERSamP).
2 Advancing work towards a comprehensive European Raptor Biomonitoring
3 Facility, capable of delivering pan-European contaminant data for chemicals
4 management, involves collaboration across these three arenas.

5 While this work is progressing under ERBFacility, LIFE APEX is working to
6 demonstrate the systematic use of contaminant data from raptors and other
7 apex predators for chemicals management. Like ERBFacility, LIFE APEX is
8 building collaborations between collections and analytical laboratories. But
9 while the focus of ERBFacility is on building networks across the collections,
10 analysis and field arenas and developing the overall Facility, the focus of LIFE
11 APEX is on demonstrating that contaminant data from apex predators has useful
12 regulatory applications, notably in relation to the REACH and Biocides
13 regulations (Alygizakis *et al* 2019, Gkotsis *et al* 2019, Koschorreck *et al* 2019).
14

15 LIFE APEX will in particular demonstrate the use of wide-scope target screening
16 (of more than 2,400 contaminants of emerging concern - CECs), wide-scope
17 suspect screening (of more than 40,000 CECs) and non-target screening of
18 samples from raptors (in the terrestrial environment) and other apex predators
19 (in the freshwater and marine environments) to help the European Chemicals
20 Agency (ECHA) prioritise substances (among the many tens of thousands
21 currently used) for more strenuous PBT assessments and identify predominant
22 chemical mixtures in biota. LIFE APEX will also demonstrate the power of
23 targeted analyses of raptor matrices to assess the effectiveness of EU chemicals
24 risk management measures. Proof of concept work on this latter demonstrator
25 is under way by the Naturalis Biodiversity Center with the UK Centre for Ecology
26 and Hydrology (which hosts the UK Predatory Bird Monitoring Scheme).
27

28 Taken together, the growing collaborations across the collections, analysis and
29 field arenas under ERBFacility and LIFE APEX offer considerable promise to
30 enhance early warning of emerging contaminant problems, for more timely
31 identification and management of persistent and bio-accumulative substances in
32 the environment, for putting risk management measures in place more quickly,
33 for better understanding predominant chemical mixtures in the environment,
34 and to ascertain whether risk management measures (and by extension
35 chemicals regulations) are actually delivering on their purpose in reducing
36 negative impacts on human and wildlife health. This will complement ongoing
37 work to monitoring impacts of contaminants on human health.⁴⁴
38

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46 prey in chemicals management”.
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53
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55
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57
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59

60 ⁴⁴ www.hbm4eu.eu
61
62
63
64
65

References

- 1 Alygizakis N, Cincinelli A, Dekker R, Gkotsis G, Duke G, Glowacka N, Knopf B,
2 Koschorreck J, Martellini T, Movalli P, Nika MC, Nikolopoulou V, Rüdell H, Shore R,
3 Thomaidis N, Treu G, Slobodnik J. (2019) *Determination of emerging substances in top*
4 *predators and their prey using state-of-the-art chemical monitoring methods*. 5th
5 International Conference on Environmental Specimen Banks, Stockholm 3-5 June 2019.
6
7 Derlink, M., Wernham, C., Bertonecelj, I., Kovacs, A., Saurola, P., Duke. G., Movalli, P. and
8 Vrezec, A. (2018) A review of raptor and owl monitoring activity across Europe: its
9 implications for capacity building towards pan-European monitoring. *Bird Study* DOI:
10 10.1080/00063657.2018.1447546.
11
12 Movalli P, Duke G, Osborn D (2008) Introduction to monitoring for and with
13 raptors. *Ambio* **37**(6), 395-397.
14
15 Duke, G., Vrezec, A., Movalli, P., Bertonecelj, I. and Wernham, C. (2018) Editorial. *Bird*
16 *Study* DOI: 10.1080/00063657.2018.1552919.
17
18 EC 2001. Directive 2001/83/EC of the European Parliament and of the Council of 6
19 November 2001 on the Community code relating to medicinal products for human use.
20
21 EC 2004a. Directive 2004/28/EC of the European Parliament and of the Council of
22 31 March 2004 amending Directive 2001/82/EC on the Community code relating to
23 veterinary medicinal products.
24
25 EC 2004b. Regulation (EC) no 726/2004 of the European Parliament and of the Council
26 of 31 March 2004 laying down Community procedures for the authorisation and
27 supervision of medicinal products for human and veterinary use and establishing a
28 European Medicines Agency.
29
30 EC 2004c. Directive 2004/35/CE of the European Parliament and of the Council of 21
31 April 2004 on environmental liability with regard to the prevention and remedying of
32 environmental damage.
33
34 EC 2006. Regulation (EC) No 1907/2006 of the European Parliament and of the Council
35 of 18 December 2006 concerning the Registration, Evaluation, Authorisation and
36 Restriction of Chemicals (REACH)
37
38 EC 2008. Directive 2008/56/EC of the European Parliament and of the Council of 17
39 June 2008 establishing a framework for community action in the field of marine
40 environmental policy (Marine Strategy Framework Directive)
41
42 EC 2009a. Regulation (EC) No 1107/2009 of the European Parliament and of the Council
43 of 21 October 2009 concerning the placing of plant protection products on the market.
44
45 EC 2009B. Regulation (EC) No 1069/2009 of the European Parliament and of the
46 Council of 21 October 2009 laying down health rules as regards animal by-products and
47 derived products not intended for human consumption.
48
49 EEA 2013. *Late lessons from early warnings: science, precaution, innovation*.
50
51 EP 2007. EP Resolution of 22 May 2007 on Halting the Loss of Biodiversity by 2010.
52 European Parliament, 2006/2233(INI).
53
54 Espín S, Garcia-Fernandez AJ, Herzke D, Shore RF, van Hattum B, Martinez-Lopez E,
55 Coeurdassier M, Eulaers I, Fritsch C, Gomez-Ramirez P, Jaspers VLB, Krone), Duke G,
56 Helander B, Mateo R, Movalli P, Sonne C, Van den Brink NW. 2016. Tracking pan-
57 continental trends in environmental contamination using sentinel raptors—what types
58 of samples should we use? *Ecotoxicol* **25**(4), 777-801.
59
60 Espín, S., García-Fernández, A. J., Herzke, D., Shore, R. F., van Hattum, B., Martínez-López,
61 E., Coeurdassier M, Eulaers I, Fritsch C, Gomez-Ramirez P, Jaspers VLB, Krone), Duke G,
62 Helander B, Mateo R, Movalli P, Sonne C, Van den Brink NW. (2016). Tracking pan-
63 continental trends in environmental contamination using sentinel raptors—what types
64 of samples should we use?. *Ecotoxicology* **25**(4), 777-801.
65

1 EU 2012. Regulation (EU) No 528/2012 of the European Parliament and of the Council
2 of 22 May 2012 concerning the making available on the market and use of biocidal
3 products.

4 EU (2014) *General Union Environment Action Programme to 2020. Living well, within the*
5 *limits of our planet*. Luxembourg: Publications Office of the European Union.
6 doi:10.2779/66315

7 Gkotsis G, Alygizakis N, Cincinelli A, Dekker R, Duke G, Glowacka N, Knopf B,
8 Koschorreck J, Martellini T, Movalli P, Nika MC, Nikolopoulou V, Ruedel H, Shore R,
9 Thomaidis NS, Treu G. Slobodnik J (2019) *Determination of emerging contaminants in*
10 *apex predators and their prey from European Specimen Banks and Natural History*
11 *Museums by High Resolution Mass Spectrometry Techniques*. 17th International
12 Conference on Chemistry and the Environment, which will be held in Thessaloniki, 16-
13 20 June 2019.

14 Gómez-Ramírez, P., Shore, R. F., Van Den Brink, N. W., Van Hattum, B., Bustnes, J. O.,
15 Duke, G., ... & Krone, O. (2014). An overview of existing raptor contaminant monitoring
16 activities in Europe. *Environ Internat* **67**, 12-21.

17 Koschorreck J, Alygizakis N, Cincinelli A, Dekker R, Duke G, Glowacka N, Knopf B,
18 Martellini T, Movalli P, Nika MC, Ruedel H, Shore R, Thomaidis NS, Treu G. Slobodnik J.
19 (2019) LIFE APEX – Systematic use of contaminant data from apex predators and their
20 prey in chemicals management. SETAC Europe 29th Annual Meeting in Helsinki, Finland
21 (26-30 May, 2019)

22 Movalli P, Dekker R, Koschorreck J, Treu G (2017) Bringing together raptor collections
23 in Europe for contaminant research and monitoring in relation to chemicals regulations.
24 *Environ. Sci. Pollut. Res.* DOI: 10.1007/s11356-017-0096-s

25 Movalli P, Krone O, Osborn D, Pain D (2018) Monitoring contaminants, emerging
26 diseases and environmental change with raptors and links to human health. *Bird Study*
27 **64**:sup1, 596-5109.

28 Ramello G, Dekker R, Duke G, van der Mije S, Movalli P. (in prep.) A review of European
29 Raptor Tissue Collections.

30 Trasande L, Zoeller, RT, Hass U, Kortenkamp A, Grandjean P, Myers JP, DiGangi J,
31 Bellanger M, Hauser R, Legler J, Skakkebaek NE, Heindel J (2015) Estimating burden and
32 disease costs of exposure to endocrine-disrupting chemicals in Europe. *J Clin Endocrinol*
33 *Metab* **100**(4): 1245-1255.

34 Walker, LA, Shore RF, Turk A, Pereira MG, Best J (2008) The Predatory Bird Monitoring
35 Scheme (PBMS) – identifying chemical risks to top predators in Britain. *Ambio* **37**, 466-
36 471.