PERSISTENT ORGANIC POLLUTANTS IN FEATHERS OF AVIAN TOP PREDATORS FROM NORTHERN ECOSYSTEMS

Jaspers Veerle L. B.[1], Covaci Adrian[2, 3], Johnsen Trond. V.[4], Eens Marcel[1], Bustnes Jan Ove[4]

1- Department of Biology, University of Antwerp, Universiteitsplein 1, 2610 Wilrijk, Belgium
2- Toxicological Centre, University of Antwerp, Universiteitsplein 1, 2610 Wilrijk, Belgium
3- Ecophysiology, Biochemistry and Toxicology, University of Antwerp, Groenenborgerlaan 171, 2020 Antwerp, Belgium
4- Norwegian Institute for Nature Research (NINA), Polar Environmental Centre, Polarmiljøsenteret, 9296 Tromsø, Norway

Introduction

Northern ecosystems are subject to major stress factors such as climate change and a great variety of pollutants, among which organic pollutants. The combination of pollutants and other stress factors has recently been shown to cause strong adverse effects, even at low levels of pollutants[1, 2]. Moreover, climate change is expected to increase pressure on northern ecosystems by altering a wide range of stressors[3, 4]. In order to assess the vulnerability of these northern ecosystems to environmental change, it is imperative to investigate the current stress posed by organic pollutants. Since organic pollutants biomagnify through the food chain, avian top predators are very interesting species to monitor[5]. However, these birds are often protected species and samples (e.g. tissues, blood, and eggs) are difficult to obtain. Recently, feathers have been proven to be useful as non-destructive and non-invasive biomonitors for organic pollutants[6-8]. Feathers can be obtained from living birds causing minimal harm or moulted feathers can be collected at the nest. Furthermore, feathers are easily stored and transported.

In 2008 an international project (RAPTOR-2015) funded by the Norwegian Research Council, was setup to investigate the impact of organic pollutants and other environmental and biological stressors on avian top predators in different northern ecosystems and to assess their potential vulnerability to environmental changes. The present work is part of an exploratory study performed in the framework of this project. Here we investigated whether levels of organic pollutants could be quantified in predatory bird feathers collected at the nest in northern Norway (Troms and Finnmark counties). If successful, easy sampling of these birds can be carried out to investigate the current levels of organic pollutants in northern Norway and to relate them to indicators of stress, such as stress hormones, immune response, fitness components, reproductive performance and survival. In addition, we also examined if the levels and profiles of organic pollutants in the feathers differed among species from different ecosystems.

Materials & Methods

Moulted feathers were collected from three raptorial species at the nest between 1999 and 2005 in Troms and Finnmark counties, Norway. The three avian top predator species included in this study were: the golden eagle (*Aquila chrysaetos*) for the mountainous ecosystem, the goshawk (*Accipiter gentilis*) for the woodland ecosystem and the white-tailed eagle (*Haliaetus albicilla*) for the coastal ecosystem. Three nests per species were sampled and from each nest two adult wing feathers were collected (total: n = 18 feathers). Feathers were sent in envelopes by mail to the Toxicological Lab at the University of Antwerp (Belgium) for analysis.

Feathers were washed with distilled water, dried at room temperature and cut in pieces of ~1 mm. An amount between 0.5 and 1.5 g feather was weighed and incubated overnight at 40°C with HCl (4N) and a mixture of hexane/dichloromethane (4:1, *v:v*). After liquid extraction, clean-up was performed on acidified silica[7]. In all samples, 19 PCB congeners (PCB 52, 74, 95, 99, 101, 105, 110, 118, 128, 138, 149, 153, 156, 170, 180, 183, 187, 194 and 199), 8 PBDE congeners (BDE 28, 47, 85, 99, 100, 153, 154 and 183), dichlorodiphenyltrichloroethane (*p,p'*-DDT) and metabolites (*p,p'*-DDE and *p,p'*-DDD), hexachlorocyclohexanes (HCHs; α-, β- and γ-HCH), chlordanes (CHLs; *cis*-chlordane (CC), *trans*-chlordane (TC), *trans*-nonachlor (TN) and oxychlordane (OxC)) and hexachlorobenzene (HCB) were analysed. For PBDEs, analysis was done using a GC/MS equipped with a DB-5 capillary column (30 m × 0.25 mm × 0.25

μm), operated in electron capture negative ionisation (ECNI) mode. PCBs and DDTs were analysed using a GC/MS equipped with a HT-8 capillary column (25 m × 0.22 mm × 0.25 μm), operated in electron ionisation (EI) mode.

Samples with levels below the LOQ were assigned a value of p x LOQ, with 'p' the proportion of measurements with levels above the LOQ. Compounds with over 50% of the measurements below the LOQ were excluded from graphical representations (i.e. BDE 85 and BDE 183). Mean concentrations of the two collected feathers per nest were determined and from these data the mean per species was calculated. No statistical analyses were performed on the data, because of small sample sizes of this pilot study. However, trends in levels and profiles of organic pollutants among the different species are discussed below.

Results and discussion

Most compounds could be quantified in the feathers of the birds under study. As shown in Table 1, PCBs were the most important compounds in all species, followed by the DDTs. PBDEs were third in row for the goshawk (GH) and the sea eagle (SE), while HCHs seemed more important in the feathers of the golden eagle (GE). Overall, concentrations were higher in the SE compared to the GH and the GE. This may be explained by the diet of the SE consisting mainly of fish and birds, which generally contain high loads of organic pollutants[9, 10]. Concentrations were generally low in the GE. This species feeds mostly on small mammals which generally are less contaminated with organic pollutants than birds, the main prey of the Goshawk[10]. However, the concentrations of HCHs were highest in the GE, which suggests maybe a higher contamination with HCHs in the mountainous ecosystem in comparison with the woodland and coastal areas. Future studies with higher sample sizes will probably elucidate this.

Table 1: Mean concentrations ± SE (ng/g feather) of organic pollutants in avian top predators from Northern ecosystems.

ng/g feather	Golden Eagle (GE) (n = 3)	Goshawk (GH) (n = 3)	Sea Eagle (SE) (n = 3)
Sum PCBs	28.25 ± 12.45	87.94 ± 42.70	128.38 ± 22.71
Sum DDTs	15.73 ± 8.10	18.20 ± 10.27	34.15 ± 7.32
Sum BDEs	0.50 ± 0.16	9.46 ± 4.70	10.63 ± 2.91
Sum HCHs	2.78 ± 1.41	0.98 ± 0.22	1.39 ± 0.16
Sum CHLs	0.29 ± 0.14	1.42 ± 0.94	5.90 ± 0.84
HCB	0.52 ± 0.03	0.50 ± 0.17	0.65 ± 0.06

The levels of organic pollutants in feathers of the SE and the GH are in the same range as the levels in feathers of predatory birds from Belgium[7]. On the other hand, the concentrations of PCBs in GE feathers were comparable to the PCB concentrations found in the feathers of the common moorhen (*Gallinula chloropus*) from Belgium, which is a non-predatory aquatic bird[7]. This underlines the low concentrations that were found in the GE from northern Norway. However, PBDEs, CHLs and HCB could not be quantified in the common moorhen, while HCB, BDE 47, 99, 100, 153 and OxC were quantifiable in more than 50% of the GE feathers. The overall high detectability of organic pollutants in the predatory bird feathers of the present study emphasises the usefulness of feathers to monitor the concentrations in northern ecosystems.

The profiles of PCBs (Figure 1), PBDEs (Figure 2) and HCHs (Figure 3) were compared among the different species. CB 153 was found to be the major congener in all species, followed by CB 180 in the GE and CB 138 in the GH and SE.

The PBDEs profile is comparable between the GH and the SE with BDE 47 as the main contributor (more than 60%) to sum PBDEs. On the other hand, BDE 47, 99, 100 and 153 had a more or less equal contribution (~ 25 %) to the PBDE profile in the GE. Added up, both concentrations and profiles of PCBs and PBDEs in feathers of the GE seem to differ from the GH and SE. This suggests that the contamination of the mountainous areas in Troms and Finnmark may be very different from the contamination of the coastal and woodland areas. Although sample sizes are small, the standard error of the mean per species is rather low (Figure 1 and 2), which indicates that this difference may be biologically important. Future studies with larger sample sizes will shed light on this issue.

Figure 1: Contribution of individual PCB congeners (mean % ± 2SE) to the total sum of PCBs in feathers of three avian top predators from northern ecosystems (Troms and Finnmark counties, Norway).

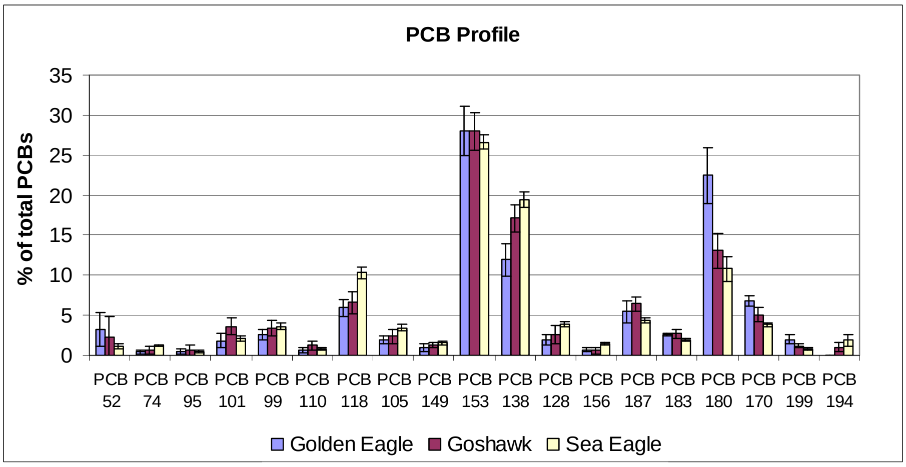
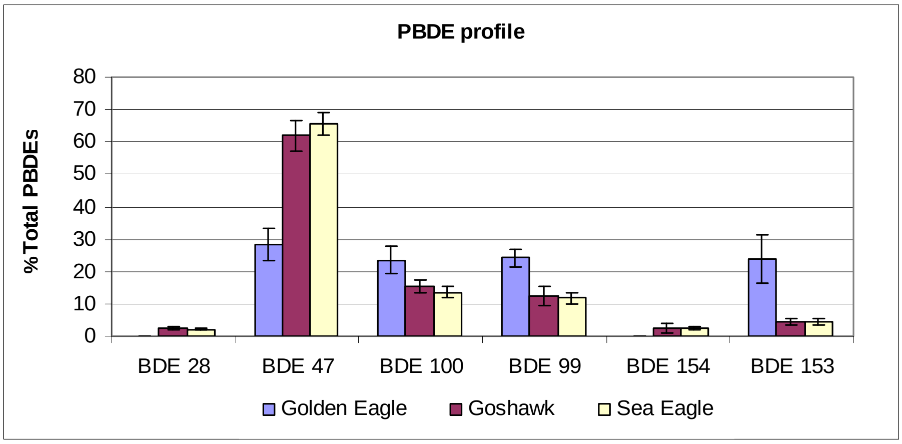
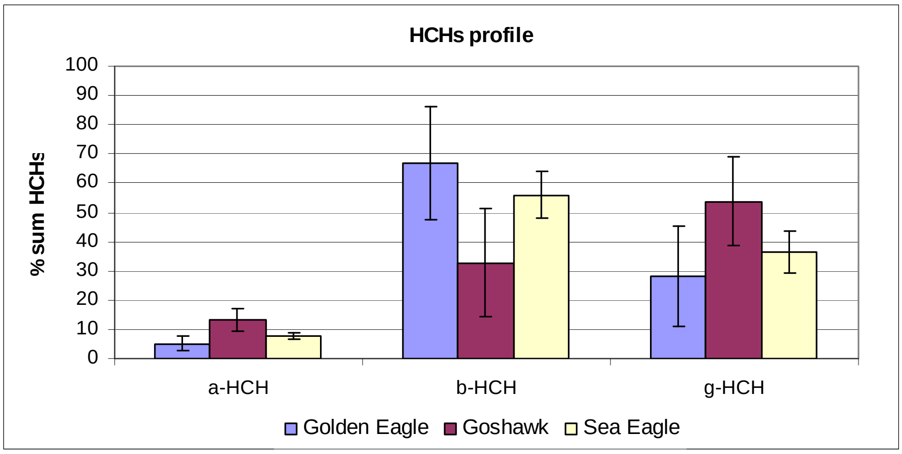


Figure 2: Contribution of individual PBDE congeners (mean % ± 2SE) to the total sum of PBDEs in feathers of three avian top predators from northern ecosystems (Troms and Finnmark counties, Norway).



The profile of HCHs is deviating for the GH (Figure 3). While β-HCH is the most important congener in the GE and SE, γ-HCH seems to be more important in the GH. The standard errors of the mean are much larger in this case, indicating that these results should be interpreted with caution.

Figure 3: Contribution of HCHs isomers (mean % ± 2SE) to the total sum of HCHs in feathers of three avian top predators from northern ecosystems (Troms and Finnmark counties, Norway).



Previous studies have shown that concentrations in feathers are significantly related to concentrations in internal tissues, blood and preen oil[6-8, 11]. We have no data on concentrations in tissues, blood or preen oil from the birds used in the present study. In order to validate the use of feathers for monitoring the concentrations of organic pollutants in the northern ecosystems as well, nestling feathers, blood, preen oil and deserted eggs (when available) will be collected in addition to moulted feathers from the adults. This way we wish to elucidate the relationship between concentrations of organic pollutants in feathers and actual concentrations in the bird's body.

Overall, the results of this pilot study indicate that feathers are useful to measure concentrations of organic pollutants in avian top predators from northern ecosystems. Furthermore, the concentrations and profiles in the feathers reflect differences among the species. However, the strength of our results should be further investigated with larger sample sizes, which will be done in the near future.

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