LEVELS OF PCBs, PBDEs & PESTICIDES IN ARCTIC FOX (*Alopex lagopus*) FROM GREENLAND AND NORTHERN RUSSIA

Lifgren H[1], van Bavel B[1], Lindström G[1], Fuglei E[2], Kapel CMO[3]

[1]MTM Research Centre, Department of Natural Science, Örebro University, Örebro, Sweden; [2] The Norwegian Polar Institute, Tromsö Norway; [3] Danish Centres for Experimental Parasitology, Royal Veterinary and Agricultural University, Copenhagen, Denmark

Introduction

Persistent organic pollutants, POPs, are absorbed by organic matter such as organic carbon, waxy plant surfaces, and lipids. Because of the low aqueous solubility, POPs deposited in the oceans from the atmosphere, bio-accumulate in the marine food web via organic matter, i.e. phytoplankton and zooplankton. Since plankton possesses a very large surface to volume ratio, POPs easily enter the marine the food web.[1] Consequently, POPs tend to magnify through the marine food chain and accumulate in the top predators.[2] Arctic foxes (*Alopex lagopus)* living in coastal habitats are likely to experience a high concentration of these anthropogenic substances.

Throughout the years there are only a few studies that have investigated the occurrences of POPs in arctic foxes. The main focus in these studies were PCBs in Svalbard, Iceland, and PCBs along with other Organochlorine contaminants, i.e. pesticides, in the Alaskan and Canadian Arctic.[3,4,5,6,7] In a newly accepted manuscript the occurrences of PBDEs, pesticides and PCBs, in artic foxes in Svalbard has recently been investigated.[8]

Material and Methods

The occurrence of PCBs, PBDE-47 and some pesticides (HCB, DDE and Chlordanes) in 6 abdominal and 4 subcutaneous fat samples from arctic foxes living in northern Russia, and in 6 liver and 6 kidney samples from arctic foxes living in Greenland has been examined.

Chemical Analysis

The samples were homogenised with Na_2SO_4 and fortified with ^{13}C-labelled internal PCB and pesticide standards. The compounds of interest were extracted from the tissue homogenates by open column extraction and the lipid content of each sample was determined. The compounds were further extracted from the lipids by multilayered silica open column extraction. In addition, one laboratory blank sample and one reference sample of each set of 8 samples were analysed. Congener specific analysis and quantification of PCBs, PBDEs, Chlordanes, DDE and HCB was performed by HRGC/HRMS analyses on an Autospec Ultima operating at 10.000 resolution using EI ionization at 35 eV. All measurements were performed in the selective ion recording mode (SIR), monitoring the two most abundant ions of the molecular cluster, as well as one ion for ^{13}C labelled internal standards (IS) and recovery standards (RS). A quantification standard mixture including all compounds in addition to the IS and RS was used to calculate relative response factors (RRF). These RRFs were used to calculate the compound levels in the samples. The recoveries of the internal standards were calculated and were all in the range of 50-150%.

Results and Discussion

Mean concentrations of Σ PCBs in arctic fox tissues from Greenland, were 2400 ng/g lw in kidney and 11000 ng/g lw in liver, and from northern Russia 1300 ng/g lw in subcutaneous and 1500 ng/g lw in abdominal fat. The values are given in Table I in addition to the ten most abundant PCBs in the samples.

Table I. Mean value for residues (ng/g, l.w.) of PCBs in kidney and liver from Greenland and in subcutaneous and abdominal fat from northern Russia. n denotes the number of samples.

Site	Greenland		northern Russia	
Tissue	Kidney	Liver	Subcutaneous fat	Abdominal fat
n	6	6	4	6
PCB-99/113	53	220	46	99
PCB-118	47	200	22	54
PCB-138	63	600	57	140
PCB-153	380	1700	470	480
PCB-156	54	240	26	30
PCB-170/190	350	1400	180	170
PCB-180/193	670	4200	340	340
PCB-194	440	1100	56	55
PCB-206	130	390	11	12
PCB-209	40	190	12	12
Σ PCB*	**2400**	**11000**	**1300**	**1500**

* Σ PCB = sum of PCB-28, 52, 47/48, 74, 66, 77, 60, 101, 99/113, 85, 110, 118, 114/122, 105, 153, 141, 138, 128/167, 156, 157, 178, 182/187, 183, 174, 177, 172/192, 180/193, 170/190, 189, 202, 201/204, 197, 199, 196/203, 195, 194, 207, 208, 206, and PCB-209.

The values presented in Table I above were not compared according to region. Although there is a difference in concentration of PCBs between the location in Russia and the location in Greenland, it can not be said whether this difference is because of the different locations or because of the different tissue analysed.

Table II. Sum of PCB values of arctic foxes from Svalbard (1973-74, 1983-84, 1991-92 and 1998-99), Iceland (1993-94), Greenland (1998-99), Russia (1999), Alaska and Canada (1999-2001).[3,4,5,8,6,7]

Location	Year	Liver (ng/g lw)	Fat(ng/g lw)
Svalbard	1973-74[3]	12400+/- 14200 (n=44)	12600+/- 14500 (n=44)
Svalbard	1983-84[4]	9700+/- 9900 (n=27)	10400+/- 14300 (n=44)
Svalbard	1991-92[5]	20500+/- 31000 (n=44)	-
Svalbard	1998-99[8]	-	12364+/-1191 (n=20)
Iceland coast	1993-94[6]	5400+/- 2000 (n=4)	-
Greenland	1998-99 (this study)	11000+/-750 (n=6)	-
Russia	1999 (this study)	-	1300+/-93 (n=4)
Alaska	1999-2001[7]	1516+/-370 (n=18)	-
Canada	1999-2001[7]	1853+/-430 (n=20)	-

Previous publications of PCBs in arctic foxes from Svalbard, Table II, showed good correlation of the Σ PCBs between liver samples and fat samples.[3,4] This implies a spatial difference in the PCB contamination between the location in Russia and the location in Greenland. However, this is conflicting to the west to east trend (Alaska to Svalbard and northern Norway/western Russia) of Σ PCBs previously found in ringed seals and polar bears. [9]

Table III. Residues (ng/g, l.w.) of HCB, p,p'-DDE, PBDE-47 and chlordanes in kidney and liver from Greenland and in subcutaneous and abdominal fat from northern Russia. n denotes the number of samples.

Site	Greenland		Russia	
Tissue	Kidney	Liver	Subcutaneous fat	Abdominal fat
n	9	7	6	7
HCB	42	220	45	42
p,p-DDE	51	240	220	120
PBDE-47	5.8	44	5.0	6.5
cis-heptachlordane epoxid	140	2100	39	50
cis-chlordane	6.3	13	4.2	3.4
trans-chlordane	18	150	20	27
oxychlordane	2300	40000	450	570
MC6	140	1700	68	91
trans-nonachlor	150	1200	44	82
cis-nonachlor	1.9	7.2	6.1	5.6
Σ Chlordanes*	**2800**	**45000**	**630**	**830**
Σ Pesticides	**2900**	**46000**	**900**	**1000**

* Σ Chlordanes = sum of *cis*-heptachlordane epoxid, *cis*-chlordane, *trans*-chlordane, oxychlordane, MC6, *trans*-nonachlor, and *cis*-nonachlor.

Compared to liver samples from arctic fox from Canada and Alaska, the concentration of DDE, Table III, in the liver samples from Greenland showed 8 times, respectively 4 times higher concentrations. It is a similar ratio for HCB, with 7 (Canada) respectively 2 (Alaska) higher concentrations in the liver samples from Greenland.[7]

Abdominal and subcutaneous fat samples from arctic foxes on Svalbard were recently analysed for PBDEs.[8] Compared to the Svalbard study, the present study gave approximately the same result of the PBDE-47 concentrations in subcutaneous and abdominal fat from Russia, and kidney from Greenland. On the other hand, the PBDE-47 concentration in liver samples from Greenland was 7 times higher. Compared to other top predators in the Arctic, the concentration of PBDE-47 in the fat (from Russia) and kidney (from Greenland) samples were 3 times lower than blubber samples from ringed seals, 5 times lower than subcutaneous fat samples from male polar bears, and 9 times lower than found in subcutaneous fat samples from female polar bears. However, the liver samples were in the same range as in female polar bears.[10]

The chlordanes, as can be seen in Table III, stand for the vast majority of the ∑ Pesticides. Most prominent is oxychlordane which made up 81%, 87%, 50% and 57%, of the total measured concentration of pesticides in kidney, liver, subcutaneous fat, and abdominal fat samples respectively. In addition, this corresponds to 43%, 71%, 20% and 23%, of the over all measured concentrations of pollutants in kidney, liver, subcutaneous fat, and abdominal fat samples respectively. Although the extreme concentrations in this study, especially in liver samples, oxychlordane has been confirmed as the compound with the single highest concentration of POPs analysed as well in liver and muscle, as in subcutaneous fat samples.[7,8] Even if this could be because of formation of this compound in lower trophic levels, the probable reason to the elevated oxychlordane concentration is metabolism of chlordane by the arctic fox itself.[11,7]

Acknowledgements
We thank A. Bambulyak for providing tissue samples from Russia.

References

1. Norstrom RJ, Muir DCG. *Sci Total Environ* 1994;154:107.
2. Hop H, Borgå K, Gabrielsen GW, Kleivane L, Skaare JU. *Environ Sci Technol* 2002;36:2589.
3. Norheim G. *Acta pharmacol et toxicol*1978;42:7.
4. Wang-Andersen G, Skaare JU, Prestrud P, Steinnes E. *Environ poll* 1992;82:269.
5. Severinsen T, Skaare JU. *The AMAP Internationel Symposium on Environmental Pollution in the Arctic*, Extended abstracts, Tromsö, Norway 1-5 june. 1997;407-409.

6. Klobes U, Vetter W, Glotz D, Luckas B, Skirnisson K, Hrtsteinsson P. *Intern J Environ Anal Chem* 1998;69:67.
7. Hoekstra PF, Braune BM, O'Hara TM, Elkin B, Solomon KR, Muir DCG. *Environ Poll* 2003;122:423.
8. Fuglei E, Bustnes JO, Hop H, Mørk T, Björnfot H, van Bavel B. *Environ Poll* 2006;Accepted.
9. Muir DCG, Norstrom RJ. *Toxicol Letters* 2000;112-113:93.
10. Wolkers H, vab Bavel B, Derocher AE, Wiig O, Kovacs KM, Lydersen C, Lindström G. *Environ Sci Technol* 2004;38:1667.
11. Fisk AT, Stern GA, Hobson KA, Strachan WJ, Loewen MD, Norstrom RJ. *Marine Poll Bulletine* 2001; 43:93.