Polybrominated diphenyl ethers (PBDE) in Danish Red Kites

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INTRODUCTION

The red kite *(Milvus milvus),* a European raptor species, currently has an estimated population in Denmark of 30-40 breeding pairs. The ecology, population dynamics, and carrying capacity of the Danish red kite are poorly understood. When compared to the relatively larger populations in neighboring Sweden and Germany, concerns have been raised that the Danish population may be "unnaturally low". Hypotheses regarding the poor breeding success and subsequent small population size include chemical contamination, poor habitat quality, and natural variation.

In 2004 and 2005 we investigated chemical contamination in juvenile Danish red kites by testing for polybrominated diphenyl ethers (PBDE). We also tested juvenile barn owls *(Tyto alba)* and European kestrels *(Falco tinnunculus)* as these species share habitat and overlap in diet with the red kite.

Tests on concentration of PBDEs in mainland Denmark has thus far been performed in herring (Clupea harengus; (Cederberg et al. 2000) blue mussels (Mytilus edulis), and sediments (Christensen and Platz 2001). This is to the best of our knowledge the first study measuring PBDE in birds in mainland Denmark.

We analyzed the following samples from red kites: 3 addled eggs, 9 whole blood, 5 livers, and 5 kidneys, from barn owls: 14 addled eggs, 12 whole blood, 11 livers, and 13 kidneys, from European kestrels: 5 addled eggs, 3 whole blood, and 2 kidneys.

SPECIES	TISSUE TYPE	BDE 28	BDE 47	BDE 99	BDE 100	BDE 138	BDE 153	BDE 154	BDE 183
RED KITE	LIVER ng/g ww	<LOD (<LOD/0.1)	0.5 (<LOD/3.9)	1.0 (<LOD/6.2)	0.3 (<LOD/0.3)	<LOD (<LOD/0.3)	0.3 (<LOD/1.5)	0.1 (<LOD/1.7)	0.3 (<LOD/3.4)
	KIDNEY ng/g ww	<LOD (<LOD/0.0)	0.55 (0.1/1.5)	0.6 (0.3/3.6)	0.2 (0.1/1.3)	<LOD (<LOD/0.2)	0.3 (0.1/3.1)	0.1 (0.1/0.8)	0.1 (<LOD/1.6)
	EGGS ng/g ww	<LOD	1.4 (0.4/2.4)	2.3 (0.5/3.4)	0.8 (0.2/1.3)	<LOD	1.2 (0.5/1.8)	0.4 (<LOD/0.5)	<LOD
	WHOLE BLOOD pg/g	<LOD	56.4 (<LOD/89.4)	107.7 (<LOD/196.0)	<LOD (<LOD/82.5)	<LOD (<LOD/187.3)	<LOD (<LOD/38.5)	<LOD	<LOD
BARN OWL	LIVER ng/g ww	<LOD	0.5 (<LOD/22.0)	1.0 (<LOD/74.0)	<LOD (<LOD/9.2)	<LOD (<LOD/2.1)	0.3 (<LOD/54.4)	0.1 (<LOD/7.2)	<LOD (<LOD/6.0)
	KIDNEY ng/g ww	<LOD (<LOD/0.4)	0.9 (0.1/8.4)	1.5 (<LOD/40.7)	0.3 (<LOD/5.8)	<LOD (<LOD/1.4)	2.1 (<LOD/34.3)	0.2 (<LOD/4.3)	<LOD (<LOD/3.1)
	EGGS ng/g ww	<LOD	1.75 (0.3/6.4)	2.6 (<LOD/13.6)	0.35 (<LOD/3.1)	<LOD	1.7 (<LOD/4.5)	<LOD (<LOD/0.7)	<LOD (<LOD/0.5)
	WHOLE BLOOD pg/g	<LOD	44.4 (<LOD/421.2)	<LOD (<LOD/881.4)	<LOD (<LOD/206.3)	<LOD	<LOD	<LOD	<LOD
EUROPEAN KESTREL	LIVER ng/g ww	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	KIDNEY ng/g ww	<LOD	0.55 (0.1/1.0)	9.7 (2.4/17.0)	3.65 (0.9/6.4)	0.35 (<LOD/0.7)	31.9 (4.9/58.9)	2.7 (1.0/4.4)	4.75 (0.9/8.6)
	EGGS ng/g ww	<LOD	0.1 (<LOD/0.1)	<LOD	<LOD	<LOD	0.5 (<LOD/0.7)	<LOD	<LOD
	WHOLE BLOOD pg/g	<LOD	117.9 (<LOD/282.1)	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD

TABLE 1: Median, minimum and maximum (min/max) concentrations of PBDEs in kidney, liver, addled egg, and whole blood samples in red kites, barn owls, and European kestrals. (n/a = not tested).

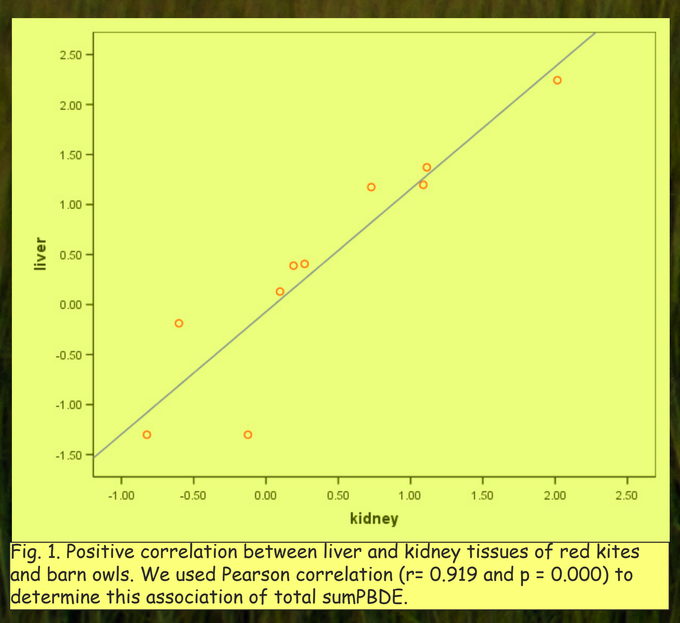

Fig. 1. Positive correlation between liver and kidney tissues of red kites and barn owls. We used Pearson correlation (r= 0.919 and p = 0.000) to determine this association of total sumPBDE.

METHODS

Laboratory

- Tissue samples were homogenized, dried with sodium sulphate, and extracted in a cyclohexane/acetone mixture (3:1).
- The amount of extractable organic material was determined gravimetrically.
- Lipid removal was performed on a gel permeation chromatography (GPC) system.
- An additional fractionation was carried out on a florisil column.
- Blood samples were extracted with a HLB Waters solid phase extraction column, followed by further clean up with florisil.
- Gas chromatographic separation and quantification was performed by GC/MS using the method described in (Herzke et al. 2005).

RESULTS

Eight BDE congeners (28, 47, 99, 100, 138, 153, 154, and 183) were analyzed in addled eggs, whole blood from nestling species and one adult red kite. Kidney, and liver tissues were collected from recovered carcasses representing all the three species.

Principle component analyses indicated that the majority of the variance was found in the sum of PBDE congeners for liver (84.4%), kidney (72.1%), blood (50%) and addled eggs (79.6%). Kidney and liver results were pooled as the statistics reflected a very strong correlation of the PBDE congener concentrations between these two tissues (Fig. 1.) by using Pearson correlation (r= 0.919 and p = 0.000). A one-way ANOVA resulted in non-significant results for both kidney and liver by species and for blood between species. Results for eggs were significant between species $F_{0.05(2,5)} = 7.981$, $p_{(0.5)}=0.010$.

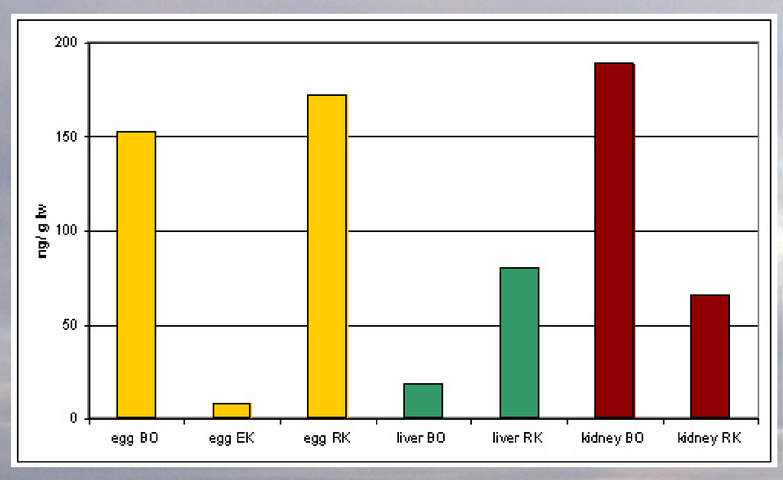

Fig. 6. sumPBDE in analysed samples of terrestrial birds of prey from Denmark in ng/g lw (BO: barn owl; EK: European kestrel; RK: red kite).

sumPBDE in analysed samples of terrestrial birds of prey from Denmark in ng/g lw.
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DISCUSSION

- We detected PBDEs in red kite, barn owls, and European kestrels in Denmark at very low concentration levels.
- Liver: a distinct PBDE pattern was observed in barn owl and red kite. BDE 99 and PBDE 153 were the dominant congeners with highest concentration in the barn owl (Fig. 4).
- Kidney: BDE 47 was only a minor congener in the kidney of all species while BDE 153 and 99 dominated the pattern (Fig. 5).
- Eggs: BDE 153 was the dominant congener in the kestrel, followed by BDE 99 in red kites and barn owls (Fig. 3).
- Kidney appers to be an important accumulation compartment for PBDEs in the barn owls compared to red kites.
- In the blood PBDE pattern is dominated by the lesser brominated PBDE , BDE 47 and 99 in contrast to the other observed tissues.

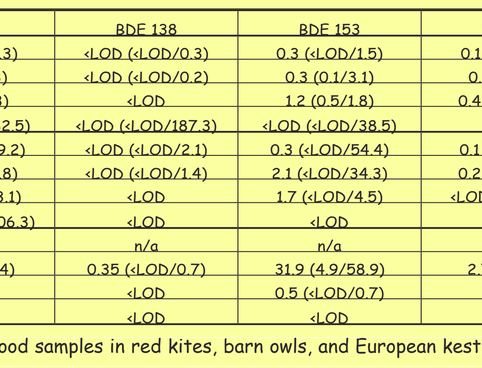

Fig. 2. Proportion of pbde in whole blood

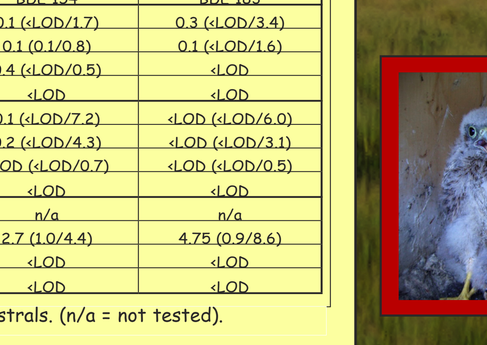

Fig.3 Proportion of PBDE concentration in addled eggs

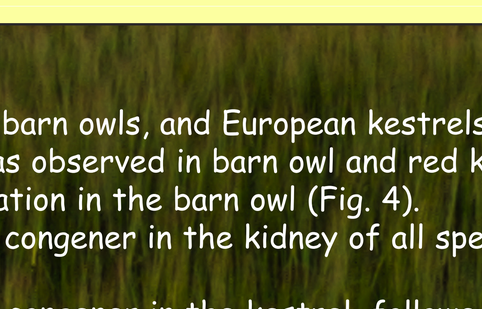

Fig. 4. Proportion of PBDE concentration in liver

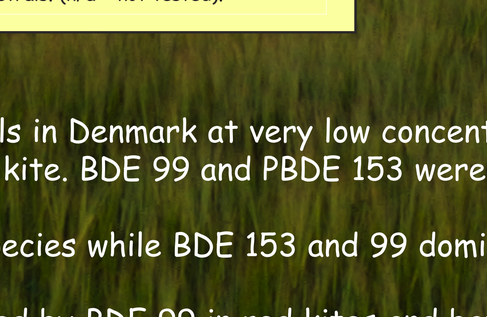

Fig.5 Proportion of PBDE concentration in kidney

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