

## PCBs in Three Predatory Birds from Galicia (NW Spain)

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Received: 11 September 2000/Accepted: 4 February 2001

Buzzard (*Buteo buteo*), barn owl (*Tyto alba*) and tawny owl (*Strix aluco*) are predatory birds which feed at the top of the food chains and they are, thus, exposed to array of persistent contaminants. The degree of the exposure of raptors to organochlorine compounds depends largely on the amounts transfer via diet. As predators they are an indicator of overall pollution in the area (Pain et al., 1999).

Amongst the important classes of persistent organic pollutants are families of chlorinated aromatics including polychlorinated biphenyls (PCBs) and polychlorinated terphenyls (PCTs). Despite restrictions on their manufacture and use, they are still of concern in species at the food chain because of their possible association with subtle sub-chronic health and reproductive effects (Seegal, 1996). Although, PCBs and PCTs have been identified and quantified in aquatic and terrestrial species, little information is available for predatory birds in Galicia (NW Spain) (Young et al., 1998; Bacon et al., 1999; Ewins et al. 1999).

The objectives of this study were to determine the degree of Aroclor 1260, Aroclor 5460 and four PCB congeners exposure of adult and juvenile buzzards, barn owls and tawny owls.

### MATERIALS AND METHODS

Twenty five birds of three different species: buzzard (*Buteo buteo*), barn owl (*Tyto alba*) and tawny owl (*Strix aluco*) were collected by Rescue Wildlife Centres of Xunta de Galicia (Galicia, Spain). They were dissected for various organs (heart, liver, kidney, intestine, muscle and lung) by Laboratory of Parasitology of Institute of Research and Food Analysis of the University of Santiago de Compostela. Then, organs were wrapped individually in aluminium foils and frozen until chemical analysis.

Samples were analysed for Aroclor 1260, Aroclor 5460 and four individual PCB congeners (PCB 101, PCB 138, PCB 180 and PCB 206), following

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the method described by López et al., 2000). This involves supercritical fluid extraction for ten minutes static and 50 minutes dynamic extraction; clean-up was carried out using a Sep-Pak® of silica.

Residues were quantified using capillary GC-ECD on a Thermoquest CE Instruments 8000 Top instrument fitted with a Sugelabor SGL-5 column (0.1  $\mu\text{m}$  of 5% diphenylmethylsilicone; 30 m. x 0.25 mm i.d.) and using nitrogen as carrier gas (flow= 1 mL min<sup>-1</sup>). The oven program was performed as Carril et al. (1996). A Thermoquest CE Instruments AS-800 autosampler was used to inject samples (1  $\mu\text{L}$ ) in split- splitless mode; the vent was open 60 s. after injection (flow rate = 30:1). Temperatures of injector and detector were 280° C and 320°C, respectively. Quantifications were carried out within the linear range of the ECD.

Mean ( $\pm$  standard deviation) recoveries for Aroclor 1260, Aroclor 5460, PCB 101, PCB 138, PCB 180 and PCB 206 were 93 ( $\pm$  4.2), 87( $\pm$  6.4), 96 ( $\pm$  3.4), 85 ( $\pm$  5.8), 95 ( $\pm$  3.4) and 95 ( $\pm$  5.5), respectively. Limits of detection ranged 0.95-7.1  $\mu\text{g Kg}^{-1}$  dry weight for individual PCB and 1.24-5.5  $\text{Kg}^{-1}$  dry weight for Aroclor 1260 and Aroclor 5460, respectively; they were calculated using the method proposed by Knoll (1985).

## RESULTS AND DISCUSSION

A total of one hundred and forty five samples of six tissue type were analysed for PCB and PCT residues of twenty five birds; six were from La Coruña (4 buzzards and 2 barn owls), one from Lugo (buzzard), five from Orense (3 buzzards and 2 barn owls) and 13 from Pontevedra (2 buzzards, 6 barn owls and 5 tawny owls). Specimen origin, sex, age and possible cause of death are listed in Table 1.

Aroclor 1260, PCB 180 and PCB 206 were identified and quantified in > 90 % of samples; PCB 138 in 35 %, PCB 101 in 10 % and Aroclor 5460 in < 1 % of them.

The arithmetic mean and median of organochlorine residue concentration in the three species are given in Table 2.

Higher mean values were found in barn owls. The ranges of PCB

congener values found were 0.01 mg  $\text{Kg}^{-1}$  dry weight for PCB 101 in buzzard and barn owl and 1.47 for PCB 180 in barn owl too. Levels of total PCBs in tawny owls were lower than those in buzzard and barn owls.

The results for all analysed samples are included in Table 3. Liver tissues generally contained more PCBs than the others. Only one intestine sample contained Aroclor 5460 (13.4 mg  $\text{Kg}^{-1}$  dry weight). This sample was from Pontevedra, a female adult of barn owl, and it was not included in

statistical analysis. There were no tawny owl sample issues which contained quantified amounts of PCB 101.

**Table 1.** Data on analyzed birds

Specimen	Nº	ORIGIN	SEX	AGE	CAUSE OF DEATH
BUZZARD	1	LA CORUÑA	FEMALE	ADULT	SHOT
	2	LA CORUÑA	MALE	ADULT	SHOT
	3	LA CORUÑA	MALE	ADULT	SHOT
	4	LA CORUÑA	FEMALE	ADULT	SHOT
	5	LUGO	MALE	ADULT	SHOT
	6	ORENSE	FEMALE	ADULT	SHOT
	7	ORENSE	MALE	JUVENILE	SHOT
	8	ORENSE	MALE	ADULT	SHOT
	9	PONTEVEDRA	FEMALE	ADULT	SHOT
	10	PONTEVEDRA	MALE	ADULT	SHOT
BARN OWL	1	PONTEVEDRA	MALE	ADULT	BEATEN
	2	PONTEVEDRA	FEMALE	ADULT	BEATEN
	3	PONTEVEDRA	FEMALE	ADULT	UNKNOWN
	4	PONTEVEDRA	MALE	ADULT	TRAMPLED
	5	PONTEVEDRA	MALE	ADULT	UNKNOWN
	6	LA CORUÑA	FEMALE	JUVENILE	TRAMPLED
	7	LA CORUÑA	MALE	ADULT	BEATEN
	8	ORENSE	FEMALE	ADULT	UNKNOWN
	9	ORENSE	MALE	ADULT	BEATEN
	10	PONTEVEDRA	FEMALE	ADULT	TRAMPLED
TAWNY OWL	1	PONTEVEDRA	MALE	ADULT	TRAMPLED
	2	PONTEVEDRA	FEMALE	ADULT	TRAMPLED
	3	PONTEVEDRA	FEMALE	ADULT	TRAMPLED
	4	PONTEVEDRA	MALE	ADULT	SHOT
	5	PONTEVEDRA	FEMALE	ADULT	SHOT

We could not distinguish the variation in the levels of individual or total PCBs among species, between sexes and between age groups. When considering PCB concentrations with respect to sampling site significant differences were found in Pontevedra. Mean levels of Aroclor 1260 in barn owls from Pontevedra were significantly greater than those from Orense. Levels of PCB138 and PCB180 were the highest in buzzards from La Coruña; total PCB levels were lower in buzzards from Orense. (Table 4). The advantages of analysis of PCBs have been widely recognized because it is well known that in the bioaccumulation process, lipophylic contaminants are retained in the animal bodies for long time.

PCB 180 is known to be an aryl hydrocarbon hydrolase inducer, based on its structural characteristics. The higher mean value was found in heart samples from barn owls. PCB 132 is also likely to be an aryl hydrolase inducer, based also on its structural characteristics. Barn owls were the most polluted samples too. (Gonzalez et al., 1991). These two congeners joined to PCB 101 form part of the seven selected in several countries as

indicators (Decision 1999/449/CE). Apart from these, PCB 206 was considered because its environment occurrence is well established.

**Table 2.** Arithmetical mean and median corresponding to the different species of studied birds (mg Kg<sup>-1</sup> dw)

Analyte	BUZZARD		BARN OWL		TAWNY OWL	
	Mean	Median	Mean	Median	Mean	Median
Aroclor 1260	4.52	2.75	6.57	11.5	3.22	2.01
Aroclor 5460	ND <sup>a</sup>	ND	ND	ND	ND	ND
PCB 101	0.01	ND	0.01	ND	ND	ND
PCB 138	0.105	ND	0.26	ND	0.06	ND
PCB 180	0.083	0.49	1.47	0.34	0.67	0.45
PCB 206	0.21	0.12	0.58	0.11	0.17	0.13
TOTAL PCB <sup>b</sup>	6.15	3.59	8.68	2.26	3.41	2.11

<sup>a</sup>ND: No detected

<sup>b</sup>TOTAL PCB= All quantified PCB expressed as Aroclor 1260

The combination of persistence and toxicity of these compounds increases their potential detrimental effects in raptors.

The toxicity of PCB isomers has also been emphasized in some endangered bird species because some of them are potent dioxin-like toxicants as PCB 180 (Hario et al., 2000).

Within each species variation in residues was presumably due to individual variation in pollutant intake and retention. The diet of Spanish buzzards includes principally insects followed by reptiles and small mammals; barn owl feeds on frogs and tawny owl feeds on mammals, mice and small voles (Cramp et al., 1989). Aroclor 1260 presented higher residue levels in barn owls; this can be attributed to greater exposure but the origin is unknown. That these species showed higher PCB contamination than the others is probably due to exposure while foraging in contaminated areas.

Age was suggested as another factor determining variations in PCB concentration in tissues of predatory birds. The age ratio of birds selected for analysis in the present study is skewed towards adults (2 juveniles, 23 adults) because of the greater conservation interest in birds which have reached breeding age. Juvenile birds, may also have lower PCB levels than adults, as they have less time to reach pharmacokinetic equilibrium with the dietary residues (Elliot et al. 1996).

No data are available to illustrate a possible interaction from other

contamination than PCBs in examined raptors. Since an individual chlorobiphenyl exhibits a unique combination of physical, chemical and biological properties, the complexity of the environmental residues and the occurrence of many other persistent xenobiotics makes it difficult to accurately assess the potential hazards to wildlife when interpreting tissue concentrations.

**Table 3.** Concentrations of contaminants in buzzard, barn owl and tawny owl tissues from Galicia, Spain

Specie	Tissue	Aroclor 1260	Aroclor 5460	PCB 101	PCB 138	PCB 180	PCB 206	TOTAL PCB <sup>a</sup>
Buzzard	Heart	4.606	ND <sup>b</sup>	0.0062	0.056	0.791	0.15	5.556
	Liver	4.344	ND	0.014	0.120	0.865	0.208	6.299
	Intestine	2.049	ND	0.0014	0.0225	0.378	0.090	2.671
	Muscle	4.955	ND	0.005	0.236	0.991	0.333	7.077
	Lung	4.202	ND	0.007	0.047	0.748	0.231	6.944
	Kidney	6.508	ND	0.009	0.143	1.123	0.211	7.735
Barn owl	Heart	8.659	ND	0.011	0.287	1.747	0.699	10.124
	Liver	8.055	ND	0.015	0.341	1.632	0.692	10.362
	Intestine	3.767	ND	0.006	1.161	1.264	0.458	6.897
	Muscle	4.315	ND	0.009	0.161	0.956	0.393	5.799
	Lung	6.814	ND	0.010	0.216	1.604	0.592	9.086
	Kidney	7.536	ND	0.021	0.253	1.621	0.633	9.671
Tawny owl	Heart	4.905	ND	ND	0.0923	0.966	0.272	5.196
	Liver	3.598	ND	ND	0.107	0.710	0.204	3.903
	Intestine	1.923	ND	ND	0.028	0.425	0.089	1.97
	Muscle	1.689	ND	ND	0.018	0.356	0.091	1.861
	Lung	3.982	ND	ND	0.084	0.911	0.215	4.031
	Kidney	3.254	ND	ND	0.059	0.655	0.179	3.984

<sup>a</sup>TOTAL PCB= All quantified PCB expressed as Aroclor 1260 <sup>b</sup>ND: No detected

**Table 4.** Levels of Aroclor 1260, Aroclor 5460 and individual PCB respect to sampling site

Specie	Sampling site	Aroclor 1260	Aroclor 5460	PCB 101	PCB 138	PCB 180	PCB 206	TOTAL PCB <sup>a</sup>
Buzzard	La Coruña	5.93	ND <sup>b</sup>	0.010	1.11	1.12	0.26	7.18
	Lugo	2.58	ND	0.014	0.01	0.78	0.16	5.56
	Orense	2.23	ND	0.004	0.09	0.41	0.12	4.01
	Pontevedra	6.18	ND	0.005	0.16	0.92	0.26	7.75
Barn owl	La Coruña	0.87	ND	0.0018	ND	0.22	0.04	1.79
	Orense	0.64	ND	0.0004	0.089	0.38	0.09	1.81
	Pontevedra	10.4	ND	0.0197	0.394	2.24	0.92	13.2
Tawny owl	Pontevedra	3.22	ND	ND	0.065	0.67	0.17	3.41

<sup>a</sup>TOTAL PCB= All quantified PCB expressed as Aroclor 1260 <sup>b</sup>ND: No detected

Its difficult to compare the present study with other studies on the subject

since little information is available specially in Galicia. Other investigators may analyse different tissues or use different method quantitation so any comparison is tentative at best. So we cannot establish if the levels are significantly different from those we found.

A conclusion based on the present study may be that despite strict regulations on PCB use introduced in the last decade in most industrialized countries, the PCB levels in the Galicia raptors are still high.

**Acknowledgments.** We thank Dr. Manuel Sanmartín Duran of Laboratory of Parasitology of Institute of Research and Food Analysis of the University of Santiago de Compostela. This study was financially supported by Consellería de Educación e Ordenación Universitaria of Xunta de Galicia, Spain (project XUGA27101B96).

## REFERENCES

- Bacon CE, Jarman WM, Estes JA, Simon M, Norstrom RJ (1999) Comparison of organochlorine contaminants among sea otter (*Enhydra lutris*) populations in California and Alaska. *Environ Toxicol Chem* 18: 452-458
- Carril González-Barros ST, Alvarez Piñeiro ME, Lage Yusty MA, Simal Lozano J (1996) Simultaneous determination of aliphatic hydrocarbons, PCBs and PCTs in pork liver by gas chromatography. *Chromatographia* 43:398-400
- Cramp S, Simmonds KEL, Gillmor R, Hollom PAD, Hudson R, Nicholson EM, Ogilvie MA, Olney PJJ, Roselaar CS, Voous KH, Wallace DIM (1989) Handbook of the birds of Europe, the Middle east and North Africa. The birds of the Western Palearctic, 4. Oxford University Press, New York, p 432 and p 526.
- Decisión 1999/444/CE de la Comisión de 9 de julio de 1999 por la que se establecen medidas de protección contra la contaminación por dioxinas en determinados productos de origen animal destinados al consumo humano o animal Diario Oficial de la Comunidad Europea L 175/70
- Elliot JE, Wilson LK, Langerlier KW, Norstrom RJ (1996) Bald eagle mortality and chlorinated hydrocarbon contaminants in liver British Columbia, Canada, 1989-1994. *Environ Pollut* 94:9-18
- Ewin PJ, Postupalsky S, Hughes KD, Weseloh DW (1999) Organochlorine contaminant residues and shell thickness of eggs from known-age female ospreys (*Pandion haliaetus*) in Michigan during 1980s. *Environ Pollut* 104: 295-304
- González MS, Fernández MA, Hernández LM (1991) Levels of chlorinated insecticides, total PCBs and PCB congeners in Spanish gull eggs. *Arch Environ Contam Toxicol* 20: 33-348
- Hario M, Himberg K, Holmen T, Rudbäck E (2000) Polychlorinated biphenyls in disease lesser black-backed gull (*Larus fuscus fuscus*) chicks from the Gulf of Finland. *Environ Pollut* 107:53-60

- Knoll JE (1985) Estimation of the limit of detection in chromatography. J Chromatogr Sci: 422-425
- López y López-Leitón TJ, Lage Yusty MA, Alvarez Piñeiro ME, Simal Lozano J (2000) Simultaneous supercritical fluid extraction of nine individual hydrocarbons, Aroclor 1260, Aroclor 5460 and four PCB congener from chicken liver Chromatographia 51: 109-111
- Pain DJ, Burneleau G, Bavoux C, Wyatt C (1999) Levels of polychlorinated biphenyls, organochlorine pesticides, mercury and lead in relation to shell thickness in marsh harrier (*Circus aeruginosus*) eggs from Charente-Maritime, France. Environ Pollut 104: 61-68
- Seegal RF (1996) Epidemiological and laboratory evidence of PCB-induced neurotoxicity. Crit Rev Toxicol 26: 709-737
- Young D, Becerra m, Kopec D, Echols S (1998) GC/MS analysis of PCB congeners in blood of the harbour seal *Phoca vitulina* from San Francisco Bay. Chemosphere 37: 711-733