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Tissue distribution of organochlorine residues – PCBs and pesticides – in Antarctic penguins

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Abstract: Antarctic penguins constitute excellent indicators of organic pollutants (PCBs, DDTs and HCHs), which reach the Antarctic either by atmospheric or maritime transport and are concentrated through the food chains. They are found mainly in lipids, both in adipose and other tissues of the organisms. Tissue samples of four gentoo and one Adélie penguins were collected during the summers of 1991, 1992 and 1993. PCBs and organochlorine pesticides (OCPs) were analysed in the adipose tissue, uropygeal gland, blood, brain, muscle, bone and liver. Organochlorines (OCs) were detected in the majority of the samples. The levels found in extractable fat were higher than in other tissues and the concentrations ranged from 42.3–1159.7 ng g^{-1} (HCB), from not detected to 39.3 ng g^{-1} (HCHs), from 30.8–972.3 ng g^{-1} (DDTs) and from 43.2–1583.6 ng g^{-1} (PCBs).

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Key words: Antarctica, organochlorine pesticides, PCBs, penguin

Introduction

Birds are in the upper levels of the trophic chain. They are key top predators in the Antarctic marine trophic chain with small fish and especially krill as their main food source and normally have the highest levels of any pollutants present in the environment, even when they are in ultra trace levels in the atmosphere or water. The distribution of these compounds in the different tissues of the organisms is controlled by the metabolic pattern and fat content of the tissues. Penguins can therefore be used to assess biological concentration factors for organochlorine pesticides (OCPs) and polychlorobiphenyls (PCBs). In the present work we have investigated the distribution of OCPs and PCBs in different tissues and organs of two species of Antarctic penguins from Admiralty Bay, King George Island, South Shetland Islands, Antarctica.

Methodology

Only male adult penguins were used in this study. Two gentoo penguins (*Pygoscelis papua*) were captured with nets in the vicinity of the Brazilian Antarctic Station Commandant Ferraz (62°05´S, 58°23´W) in February 1991. Two other penguins, one gentoo and one Adélie penguin (*Pygoscelis adeliae*) were found dead in the vicinity of the Polish Antarctic Station H. Arctowski (62°09´S, 58°28´W) in February 1992, and the last one, a gentoo was found dead in the fishing net in February 1993 in front of the Brazilian Station.

Blood samples were taken from the vein under the wing of the two living birds before sacrificing them. Samples from the brain, muscular tissue, liver, bones, fat reserves and uropygeal gland were taken from all penguins. Solid samples were wrapped in clean aluminum foils and stored at -15°C. Five ml of each blood samples were mixed with 5 g of anhydrous Na_2SO_4 and ground in a mortar. Ten grams of the other samples were also ground with an equal weight of anhydrous Na_2SO_4 after thawing. Samples were soxhlet extracted with hexane pesticide grade for 8 h. Clean-up followed the procedure of Steinwandter (1982), separation of the PCBs from OCs pesticides by the method of Erney (1974). Final analysis was done by glass packed column GC. Confirmation of OCs residues analysis was done by capillary GC. Recovery tests for the entire analytical procedure were done with standards as described in Lara *et al.* (1990) and were in the range 85–103%. For the PCBs identification and quantification, Aroclor 1254 and 1260 standards as well as ten PCB congeners (18, 52, 44, 101, 118, 153, 138, 187, 128 and 180) were used. The accuracy of the method was 5–15% depending on the OC analysed.

Results and discussion

As shown in Table I, levels of HCB, α-HCH, β-HCH, Dieldrin, Endrin, op'-DDT, pp'-DDD, pp'-DDE, pp'-DDT and PCBs were detected in the majority of the samples.

In extractable fat of Adélie penguin, OCs levels are similar to the prior work of Lara *et al.* (1990) that reported HCB levels from 21.9–448.2 ng g^{-1}, HCHs from 0.8–21.7 ng g^{-1}, DDTs from 21.9–312.0 ng g^{-1} and PCBs from 63.2–187.5 ng g^{-1}. Our DDTs levels are of the same order as those found by Subramanian *et al.* (1986) while PCBs levels are lower.

In gentoo penguins, HCB was found in all samples: 3.2–6.4 ng g^{-1} in brain, 0.1–1.0 ng g^{-1} in liver and 0.2–0.6

Table I. Organochlorine residues in penguin tissues (ng g^{-1} wet wt).

PCB congener	sample	brain	liver	muscle	blood	bone	uropygeal gland	fat	OC pesticides	sample	brain	liver	muscle	blood	bone	uropygeal gland	fat
	1	nd	0.9	nd	4.5	nd	nd	nd		1	4.4	1.0	0.6	1.5	8.5	164.6	201.7
	2	0.2	0.2	nd	2.0	0.2	nd	6.1		2	3.2	0.1	0.2	0.4	12.0	42.3	56.7
18	3	nd	nd	nd		nd	nd	nd	HCB	3	3.5	0.6	0.3		2.9	444.4	782.0
	4	0.4	0.9	0.8		1.9	13.7	28.2		4	6.4	0.9	0.4		4.1	679.7	1159.7
	5	nd	nd	nd		0.6	6.1	nd		5	9.0	1.1	0.5		5.0	257.0	275.0
	1	0.9	0.7	nd	1.8	nd	nd	nd		1	nd	0.1	nd	1.0	0.7	17.1	18.0
	2	nd	0.1	nd	nd	nd	nd	nd		2	0.1	nd	0.1	0.4	0.6	5.0	2.7
52	3	nd	nd	nd		nd	nd	nd	α-HCH	3	0.2	nd	nd		nd	nd	nd
	4	0.1	0.3	0.3		0.6	3.2	8.2		4	0.1	0.1	0.1		0.1	1.1	0.8
	5	nd	nd	nd		0.6	nd	nd		5	0.2	0.1	nd		0.1	nd	nd
	1	1.3	nd	nd	1.5	nd	nd	nd		1	0.2	nd	0.8	1.2	2.9	7.2	5.0
	2	nd	0.1	nd	nd	nd	nd	nd		2	0.2	nd	nd	6.7	2.8	4.5	3.4
44	3	nd	nd	nd		0.4	10.2	nd	β-HCH	3	nd	nd	nd		0.1	nd	nd
	4	0.3	0.2	0.2		0.3	nd	10.7		4	0.1	0.1	nd		0.6	7.8	2.4
	5	1.0	0.3	nd		0.4	nd	nd		5	0.7	0.5	nd		1.2	nd	nd
	1	0.6	0.6	nd	0.1	nd	nd	9.5		1	0.1	nd	0.4	0.6	0.1	15.0	1.9
	2	nd	nd	nd	nd	0.2	4.4	nd		2	0.2	nd	0.1	0.2	0.1	2.5	1.9
101	3	nd	nd	nd		0.4	22.7	6.2	γ-HCH	3	0.1	nd	nd		0.2	nd	nd
	4	nd	nd	0.1		0.2	nd	4.9		4	nd	nd	0.1		0.1	2.1	0.8
	5	nd	nd	nd		nd	4.3	nd		5	0.2	0.4	nd		0.3	nd	nd
	1	0.3	0.2	nd	nd	nd	nd	10.1		1	0.3	0.1	1.2	2.8	3.7	39.3	24.9
	2	nd	nd	nd	nd	nd	nd	nd		2	0.5	nd	0.1	7.3	3.5	12.0	8.0
118	3	nd	nd	nd		nd	24.1	7.1	Σ-HCH	3	0.4	nd	nd		0.3	nd	nd
	4	0.1	nd	0.2		0.3	nd	6.2		4	0.2	0.1	0.1		0.8	10.9	4.0
	5	nd	nd	nd		0.4	9.5	6.9		5	1.1	1.0	nd		1.6	nd	nd
	1	2.7	0.7	0.2	1.1	0.2	6.1	17.4		1	0.4	0.5	0.1	1.7	1.7	18.8	12.7
	2	nd	nd	nd	nd	0.2	7.2	nd		2	0.0	nd	nd	0.4	0.7	8.4	6.9
153	3	nd	nd	nd		1.9	47.4	16.7	Dieldrin	3	0.3	0.1	0.1		0.4	44.4	35.0
	4	0.2	nd	0.1		0.4	4.1	14.5		4	0.3	0.1	0.1		0.7	64.0	106.7
	5	0.7	nd	nd		2.9	11.3	8.8		5	0.5	0.1	0.1		0.4	21.4	33.0

nd: not detected (< 0.1 ng g^{-1} for organochlorine pesticides and PCB congeners and < 1.0 ng g^{-1} for ΣPCB as Aroclor 1260)
samples 1,2, 3 and 4 are gentoo penguins and sample 5 is Adélie penguin.

ng g^{-1} in muscle. Boer & Wester (1991) also found similar levels in brain, liver and muscle.

Variability of HCHs, DDTs and PCBs for the gentoo penguins in brain, liver and muscle was acceptable but for fat and uropygeal gland the dispersion was high.

Highest levels of HCH residues were those of β-HCH in brain, liver, muscle and blood samples. This is in agreement with the data obtained for penguin tissues by Boer & Wester (1991). Normally β-HCH is the more persistent of the isomers of HCH, but in some fat and uropygeal gland samples we found more α isomer than the β isomer. It is worth mentioning that the HCH used for decades in South America was the technical BHC, which contains 75% of the α isomer.

DDTs levels in brain are similar and in liver and muscle are close to the detection limit. In blood, bone and extractable fat values are more dispersed. Although pp'-DDE is the main fraction of DDT, pp'-DDT also occurs, suggesting that usage of DDT in the Southern Hemisphere is still significant.

Dieldrin and Endrin levels were detected in brain, liver and muscle in the same order of magnitude as found by Boer & Wester (1991), with exception of Dieldrin results in liver which were higher. Dieldrin (6.9–106.7 ng g^{-1}) and Endrin (0.8–49.3 ng g-1) were also detected in extractable fat.

PCB levels in fat varied from 43.2–316 ng g^{-1}, with exception of sample 5 that showed the highest level of all: 1583 ng g^{-1}. PCBs profiles matched most closely to Aroclor 1260, which was confirmed by capillary CG analysis, where the heavier congeners 138, 153 and 180 occur in all samples.

The predominant PCB congener in almost all penguin tissues was PCB-138. The incidence of congeners in the uropygeal gland, fat and bone was very similar: 153, 138 and 187. In brain the order was 138, 153, 187 and 44. In muscle was 153 and 138. In liver was 138, 18 and 52 and 44. In

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Table I. Organochlorine residues in penguin tissues (ng g^{-1} wet wt) cont.

PCB congener	sample	brain	liver	muscle	blood	bone	uropygeal gland	fat	OC pesticides	sample	brain	liver	muscle	blood	bone	uropygeal gland	fat
	1	2.2	0.8	0.3	2.2	0.1	7.1	7.3		1	0.1	0.2	nd	nd	0.2	3.0	3.3
	2	0.2	0.1	nd	1.3	0.3	20.7	5.6		2	0.1	nd	nd	nd	0.3	2.6	0.8
138	3	nd	nd	nd		0.2	32.4	11.6	Endrin	3	nd	nd	nd		0.1	9.4	12.0
	4	0.2	0.1	0.1		0.3	3.0	10.0		4	0.1	nd	nd		0.4	32.2	49.3
	5	1.6	0.2	0.2		1.0	13.0	7.4		5	nd	nd	nd		0.3	17.4	18.2
	1	0.6	0.1	nd	nd	0.3	7.8	16.5		1	0.6	0.3	0.1	0.7	1.8	30.0	91.6
	2	nd	nd	nd	nd	0.4	8.1	5.0		2	0.1	nd	0.1	0.8	1.9	26.6	27.0
187	3	nd	nd	nd		0.2	94.0	32.3	pp'-DDE	3	0.4	nd	nd		0.6	118.7	302.6
	4	0.3	nd	0.1		0.6	3.9	15.0		4	2.5	0.2	0.2		6.6	392.7	861.7
	5	1.4	0.2	nd		1.0	31.6	22.4		5	1.9	0.3	nd		2.9	139.4	176.0
	1	nd	0.3	nd	nd	nd	nd	7.2		1	nd	nd	nd	nd	0.1	8.2	5.6
	2	nd	nd	nd	nd	nd	nd	nd		2	0.4	nd	nd	1.5	nd	nd	nd
128	3	nd	nd	nd		0.4	nd	4.1	pp'-DDD	3	nd	nd	nd		nd	nd	nd
	4	nd	nd	0.1		0.1	nd	nd		4	nd	nd	nd		0.4	51.4	54.4
	5	nd	nd	nd		0.4	3.8	nd		5	nd	nd	nd		nd	nd	nd
	1	nd	0.2	nd	0.8	nd	nd	3.8		1	nd	nd	nd	nd	0.3	6.0	5.1
	2	nd	nd	nd	nd	nd	nd	nd		2	nd	nd	nd	0.5	0.5	3.3	2.1
180	3	nd	nd	nd		0.2	27.3	8.2	op'-DDT	3	nd	nd	nd		nd	5.3	3.3
	4	0.1	nd	0.2		0.3	2.1	10.0		4	0.2	nd	nd		0.3	24.3	22.6
	5	0.6	nd	nd		1.7	13.2	4.6		5	1.2	nd	nd		nd	7.5	nd
	1	3.3	nd	nd	2.2	6.1	76.7	152.8		1	nd	nd	nd	nd	0.7	10.8	41.2
	2	nd	nd	nd	4.8	2.7	48.2	43.2		2	nd	nd	nd	0.7	0.8	2.5	1.7
ΣPCB	3	nd	nd	nd		2.1	308.5	316.5	pp'-DDT	3	nd	nd	0.2		nd	8.0	10.7
	4	7.8	1.1	nd		16.5	1047.3	1583.6		4	0.2	0.3	0.2		0.3	29.3	33.7
	5	4.8	nd	nd		32.1	77.3	72.7		5	1.0	0.1	nd		nd	12.0	25.0
										1	0.6	0.3	0.1	0.7	2.9	55.0	143.4
										2	0.5	nd	0.1	3.6	3.2	32.4	30.8
									Σ-DDT	3	0.4	nd	0.2		0.6	132.0	316.6
										4	2.9	0.5	0.3		7.6	497.7	972.3
										5	4.2	0.4	nd		2.9	158.9	201.0

nd: not detected (< 0.1 ng g^{-1} for organochlorine pesticides and PCB congeners and < 1.0 ng g^{-1} for ΣPCB as Aroclor 1260)
samples 1,2, 3 and 4 are gentoo penguins and sample 5 is Adélie penguin.

blood was 138 and 18.

Borlakoglu & Haegele (1991), comparing aspects of the bioaccumulation metabolism and toxicity of PCBs, suggest that only a selective group of isomers and congeners were enriched in tissues due to their structures. The substituted meta-para-carbon atoms at both phenyl rings - as in PCBs 138, 153, 187 and 180 - facilitates the accumulation in the tissues. The trends of our PCBs congeners in the fat, bone and uropygeal penguin tissues, agree perfectly with that suggestion.

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References

Boer, J. De & Wester, P. 1991. Chlorobiphenyls and organochlorine pesticides in various subantarctic organisms. *Marine Pollution Bulletin*, **22**, 441-447.

Borlakoglu, J.T. & Haegele, D. 1991. Comparative aspects on the bioaccumulation, metabolism and toxicity with PCBs. *Comparative Biochemistry and Physiology*, **100C**, 327-338.

Erney, D.R. 1974 Rapid screening method for analysis of chlorinated pesticides and chlorinated biphenyl residues in fish. *Journal of the Association of Official Analytical Chemists*, **57**, 576-579.

Lara, W.H., Barreto, H.H.C., Inomata, O.N.K., Montone, R.C. & Weber, R.R. 1990. Organochlorine residues in Antarctic penguins. *Pequisa Antártica Brasileira*, **2**,1-6.

Steinwandter, H. 1982 Contribution to silica gel application in pesticide residue analysis. *Fresenius Zeitschrift fur Analytische Chemie*, **312**, 342-345.

Subramanian, A., Tanabe, S., Hidaka, H. & Tatsukawa, R. 1986. Distribution and transfer of organochlorines in Adélie penguins (*Pygoscelis adeliae*) in a breeding season. *Memoirs of National Institute Polar Research, Special Issue*, **40**, 423-433.

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