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Organochlorine Residue Levels and Bioconcentration Factors in Otters (*Lutra lutra* L.) from Northeast Spain

J. M. López-Martín,[1] J. Ruiz-Olmo[2]

[1]Department of Animal Biology (Vertebrate Unit), University of Barcelona, Avda. Diagonal 645, Barcelona 08028, Spain
[2]Serv. Protecció i Gestió de la Fauna, D. Gral Medi Natural, Department of Agriculture, Ramaderia i Pesca, Gran Via de les Corts Catalanes 612, Barcelona 08007, Spain

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The dramatic reduction observed in the distribution of the Eurasian otter (*Lutra lutra*) during the latter half of this century has been largely attributed to pollution (MacDonald, 1991). Attention has focused on organochlorine compounds, in particular PCB (Mason 1989; Olsson and Sandegren 1991; MacDonald and Mason 1992). The scarcity of the otter, and protection afforded, has meant tissue samples are difficult to obtain and has led to fish, the principal prey, being used in many studies (Hider et al. 1982; Olsson and Sandegren 1991; Smit and de Jongh 1991).

Studies combining both otter and fish tissue samples from the same location, however, are rare (Foley et al. 1988; Smit and de Jongh 1991) due primarily to the difficulty of obtaining samples of this mustelid. Bioconcentration factors of these pollutants have not, therefore, usually been calculated for this species in the wild. To address this shortcoming fish were analyzed from sites where otter samples were taken. Fish constitute between 95-100 % of the otter's diet in the area of study (Ruiz-Olmo 1995). This area is constituted by three rivers (Noguera Ribagorzana, Noguera Pallaresa and Segre) where live the last otter populations in Catalonia (Ruiz-Olmo 1995). These populations are completely isolated by unsurmountable dams built in narrow gorges.

The bioconcentration factors thus obtained allow theoretical concentrations of these compounds in otter tissues to be calculated from the mean levels found in fish:

MATERIALS AND METHODS

Six otters were found dead by different causes: road-traffic accident (4), hunted (1) and mother killed (1), in the N.E. Spain between 1988 and 1993. The corpses were frozen at -20 °C until post-morten analysis. Each specimen was sexed (4 males and 2 females), measured and removed the canine tooth to age (2 of 0+, and 1 of 1+, 2+, 4+ and 6+ year category). Tissue samples from the leg muscle and liver were removed for organochlorine analysis. These data are included in another fuller study about the otter pollution in Spain (Ruiz-Olmo et al. in press). Fish, captured using electro-fishing, were taken from the stretch of the river (0-15 km.) where the otters had been found. These were also frozen until the analysis when the weight and length were measured (Table 1). Fish tail muscle was used for chemical analysis.The samples were analyzed using gas chromatography, following the method described by López-Martín et al. (1994).

Correspondence to: J. M. López-Martin

Table 1. Fish species composition of each river with arithmetic mean weight (g) and percentage of extractable fat in muscle of each species (standard deviation is showed in brackets).

Ecol. niche	Species	N. Ribag.	N. Pallar.	Segre	Weight	%Ext. Fat
Carnivores	*Salmo trutta* Trout			2	169.19 (160.53)	0.65 (0.38)
	Micropterus salmoides Largemouth bass			1	114.69	1.44
	Leuciscus cephalus Chub			1	106.13	0.54
Omnivores	*Barbus haasi* Barb	9		5	157.20 (122.14)	1.34 (0.80)
	Chondrostoma toxostoma French nase		7	1	28.93 (9.10)	1.40 (0.37)

Recoveries for organochlorine compounds ranged from 82-101 % (n= 12). The limit of detection was 1 µg/g of fat. All samples were analyzed for p,p'-DDE, o,p'-DDD, p,p'-DDD, o,p'-DDT, p,p'-DDT and 18 PCB congeners of Aroclor 1260 (IUPAC N°: 95, 101, 138, 141, 151, 153, 170, 171+202, 174, 180, 182+128, 187, 194, 195, 201, 203+196). The sum of the five DDT metabolites is showed as tDDT and the sum of PCB congeners as PCB.

Levels are expressed as µg/g on a lipid weight basis to reduce variability, and allow comparisons (intra- and interspecific). Common logarithm transformation (log_{10}) were used in all data analysis to better satisfy conditions for normality as measured by the coefficient of Kolmogorov-Smirnov. The results are expressed as geometric means due to the small number of available samples. The weight and percentage of extractable fat are expressed as arithmetic mean. One way analysis of the variance (ANOVA) was used to compare differences between sample locations and species. Simple regression was used to determine correlations between fish and otter.

The index DDE/DDT was only calculated with the p,p'-homologues, and all DDT homologues were used to calculate the DDT/PCB index. The bioconcentration factor (BCF), calculated for each group of compounds, was considered to be the index between the mean values in fish and otters.

RESULTS AND DISCUSSION

The analysis in otters revealed a predominance of PCB over the tDDT (Table 2), with a mean value of 19.96 µg/g. This value is significantly lower than the mean for Spain (Ruiz-Olmo et al. in press) and comparable to that obtained in countries with good otter populations, for example, Ireland (Mason and O'Sullivan 1992) or Norway (Sandegren et al. 1986). The value is also lower than the 50 µg/g reported to produce reproductive failures in American mink (Jensen et al. 1977; Kihlström et al. 1993). Only one sample exceeded this value. The mean tDDT value obtained (4.99 µg/g) is substantially lower than that obtained for Spain as a whole (21.14 µg/g).

Mean PCB levels in fish (6.05 µg/g) were significantly lower than in otters ($p<0.02$), while for tDDT (3.16 µg/g) was not different. For the calculated indices, no significant difference was found between fish and otters for DDT/PCB ($P<0.18$), although the mean value in otters was lower in the three rivers, indicating more effective PCB accumulation in the mammal. For the DDE/DDT

index the difference was lower, but the mean values in otter are higher than in fishes from the same location, showing that the intake of DDE is higher in the top of the food chain.

Table 2. Geometric mean levels (µg/g lipid) and ranges for each group of compounds and calculated index for otters and fish for the three rivers studied. The arithmetic mean of the percentage of extractable fat for each group of samples is showed (standard deviation in brackets). For each river the bioconcentration factor (BCF) was calculated. Mean contaminant levels log10 transformed were compared using ANOVA between otters and fishes (* p< 0.02; n.s. not significant).

	% Ext. fat	tDDT	PCB	DDE/DDT	DDT/PCB
Ribagorzana					
Otters	1.327	4.609	16.552	0.653	0.301
n= 4	(0.181)	1.58-26.71	7.21-64.28	0.281-0.924	0.219-0.390
Fishes	1.443	0.966	2.030	0.565	0.357
n= 7	(0.384)	0.332-3.916	1.37-3.14	0.195-0.893	0.112-0.962
BCF		4.8	8.2		
Pallaresa					
Otters	0.716	6.150	24.712	0.825	0.362
n= 1					
Fishes	1.803	6.947	6.617	0.480	0.901
n= 9	(0.509)	2.444-20.91	3.103-17.26	0.056-0.794	0.437-1.36
BCF		0.9	3.7		
Segre					
Otters	1.306	5.595	34.095	0.680	0.160
n= 1					
Fishes	0.699	5.080	15.423	0.471	0.234
n= 10	(0.482)	1.291-24.71	4.795-58.69	0.172-0.839	0.068-0.755
BCF		1.1	2.2		
TOTAL					
OTTERS		4.994	19.960	0.664	0.266
FISHES		3.163	6.047	0.499	0.401
Signific.		n.s.	*	n.s.	n.s.
BCF		1.4	2.9		

ANOVA showed differences for levels of PCB in fish between the three rivers ($p<0.009$). For tDDT levels only significant differences was found between Ribagorza and Pallaresa fish ($p<0.0002$). Only the DDT/PCB index of Pallaresa fish was different of the rest ($p<0.01$), since it showed the highest value, indicating a greater proportion of PCB in the samples. However the same index for the otter from this location did not show a proportional increase. For DDE/DDT index no differences were found between the fish location.

Bioconcentration factor (BCF) values are close or greater than 1 (Table 2), in agreement with most studied trophic chains (Mackay 1982; Shaw and Connell 1989). The highest mean bioconcentration value was obtained for PCB, the lower bioconcentration of tDDT could be due to a greater degradation, metabolization and excretion (Larsson et al. 1990). Among rivers the BCF results showed 4- and 5-fold variability for PCB and tDDT, respectively. The BCF in otter is higher when the levels in fish are lower. In spite of the fact that only three locations were compared, the contaminant levels indicate a relationship between the accumulation of PCB in the otter and the levels of these compounds in fish ($r=0.99$; $p=0.021$). This relationship was found to be highly correlated in American river otter (*Lutra canadensis*) and mink (*Mustela vison*), with fish from the same place (Foley et al. 1988); with a great number of paired samples of mustelids and their main prey.

Bioconcentration in Eurasian otter was also demonstrated in a recent study by Smit and de Jongh (1991) in Holland, who measured levels in otters and eels (*Anguilla anguilla*). Eels, however, represent only a small proportion of the prey consumed by otters in that area, and are, furthermore, migratory, which could lead to an overestimation of the results.

Although data from small sample sizes are less representative of actual residue concentrations in fish and otter, our BCFs agree, within an order of magnitude, with previous results obtained with American river otter (Foley et al. 1988) and supply additional data on the scope of this value in the wild.

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