EVALUATING A MATHEMATICAL MODEL TO PREDICT POLYCHLORINATED BIPHENYL (PCB) LEVELS IN LIVERS OF THE OTTER (*LUTRA LUTRA*) FROM CONCENTRATIONS IN FISH

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1. Introduction

The European otter (*Lutra lutra*), once a widespread species on the Eurasian continent showed a decline in numbers in most countries of Western Europe and became extinct in some of these countries[1]. Environmental contaminants, especially polychlorinated biphenyls (PCBs) are blamed to be responsible for the steep decline which occured also where hunting was banned and in areas without obvious habitat destruction[2].
Calculating otter tissue levels of PCBs from concentrations in fish would be of a very great advantage as only a limited number of dead otters, mostly killed by traffic accidents or drowned in fish nets, are available for chemical analysis. Smit (1990)[3] and Leonards et al. (1994)[4] established such an equation to calculate the PCB levels in otter livers from fish levels. The aim of the present study is to validate this mathematical model using PCB residues in fish and otter tissues from Central Europe, an area which holds a strong population[5].

2. Materials and Methods

Nine otters found dead as road victims between 1990 untill the end of 1994 in the Waldviertel/Lower Austria were collected for residue analysis. Tissues of two animals found dead just opposite the border in the Czech Republic were included in this study. All otters were deepfrozen as soon as possible. Prior to necropsy and the collection of tissue specimen otter carcasses were allowed to thaw for at least 24 hours. Fish were obtained from local fishermen and were deepfrozen on the day of collection. In the laboratory all samples (otter liver and fish muscle) were weighed, cut into small pieces and mixed with sodium sulfate. After addition of internal standard (PCB 53) the material was soxhlet-extracted with hexan for six hours. In an aliquot of the extract the fat weight was determined by drying and weighing. The extract was cleaned up in two steps on columns filled with aluminium oxide and thereafter on a silica-filled column. PCBs were analysed with a Hewlett-Packard 5890 Series II gas chromatograph with an ECD using a 50m x 0,2mm ID (0,33μm) Ultra 2 Hewlett Packard column with N_2 as carrier gas and external standards of each compound. Recovery level of reference standard samples and internal standard was always greater than 80%, and the coefficient of variation of five replicates was <10%. Limit of detection was 0.01 mg kg^{-1}. Units are mg kg^{-1} lipid weight. Total PCB concentrations were calculated by addition of the individual concentrations of seven congeners (IUPAC nr. 28, 52, 101, 118, 138, 153 and 180).

The PCB body burdens in otter livers are calculated from the PCB content in fish following the one-compartment model of Leonards ct al. (1994)[4]:

$$Cm = a\, b\, R\, Cf \frac{1 - e^{-kt}}{k}$$

where

- Cm is the PCB content in otter tissue (mg kg^{-1} lipid weight)
- a is the assimilation efficiency of otters for PCBs (0.916)[3]
- b is the conversion factor from fresh weight to lipid weight (29.69)[6]
- R is the food ration, g food per day per g body weight (0.125)[7]
- Cf is the content of PCB in food (fresh weight)
- k is the excretion constant (0.007, derived from a half life of PCBs in mink of ca. 98 days[4,8]
- t is the time over which PCBs are calculated (days), 730 days in the present study, because otter first breed at 2 years of age[9] and it is the impact of PCBs on reproduction which is of most concern

3. Results

In all samples PCBs were detected. The results are given in table 1.

Table 1. Content of PCBs in fish (mg kg^{-1} fresh weight) and otter liver (mg kg^{-1} lipid weight)

	n	arithmetic mean	range
fish	42	0.011	0.003-0.056
otter liver	11	54.33	4.2-130.2

PCB levels in otter liver showed a great variance with a minimum of 4.23 mg kg^{-1}, a maximum of 130.2 mg kg^{-1}. The mean concentration was 54.33 mg kg^{-1}.
PCBs were detected in all fish in concentrations ranging from 0.003 mg kg^{-1} up to 0.056 mg kg^{-1} and a mean concentration of 0.011 mg kg^{-1} on a fresh weight basis. From these data potential PCB levels accumulated over a two years period in otter liver were calculated using the mathematical model. The expected range of 1.45 - 27.03 mg kg^{-1} derived from the calculation is lower than what was found in the otter livers. The mean concentration in otter livers is expected to be 5.31 mg kg^{-1}, which is an order of magnitude lower than the analysed concentrations.

4. Discussion and Conclusion

To what extent is it possible to predict the levels of PCBs in otter livers from the contents measured in fish? The mathematical model used to predict otter liver concentrations failed to explain the range and the mean values in otter livers.
One possible explanation for the observed differences might be the the ability of otters to travel over long distances in only a few days[10]. Thus otters might accummulate PCBs in some areas of Czechia where fish are known to have higher levels than what is found in fish of this study. There are data for some fish from only a few kilometers downstream the Austrian border where the mean PCB level was 0.069 mg kg^{-1} with the highest level of 0.403 mg kg^{-1} found in a roach (*Rutilus rutilus*)[11]. These

two levels in fish would theoretically result in PCB levels in otter livers of 33.31 mg kg^{-1} as a mean and 194.53 mg kg^{-1} as a maximum concentration, which is somewhat closer to the actual levels of this study.
Furthermore differences in body burdens between sexes are not considered in the model. For some species of marine mammals differences of PCB levels between sexes have been reported[12]. As a result of excretion of lipophilic substances via milkfat females may have lower PCB body burdens than males. The percentage of males in this study (89%) might therefore be responsible for the high mean of PCB levels.
Age composition of the animals might also influence PCB levels as older animals irrespectively of their sex may accummulate higher levels of pollutants. No age data are available for the animals in our sample thus an influence of age cannot be verified in the moment.
Further investigation on the correlations of PCBs in fish and otters are therefore recommended as a method for indirect estimation would be of invaluable value for risk estimations in regard to the otter.

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