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Organochlorine Residues and Heavy Metals in Kidneys of Polecats (*Mustela putorius*) from Switzerland

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Polecats (Mustela putorius) have declined in Switzerland and other parts of Europe since the middle of this century (Eiberle 1969; Mermod et al. 1983; Libois 1984; Weber 1988). Structural changes of the countryside resulting from modern agriculture, expansion of urban areas, destruction of wetlands and watercourses etc. may have affected polecat populations. However, pollutant burdens in polecats have not been studied, though contamination with organochlorines and heavy metals has been strongly linked with the decline, over the same time scale, of top carnivores such as the otter (Lutra lutra) and several species of raptor (Mason and Macdonald 1986; Newton 1979) in Europe. Polecats in Switzerland are specialized anuran predators, Rana temporaria and Bufo bufo featuring prominently in the diet (Weber 1989a). This semi-aquatic diet may render polecats more vulnerable to biomagnifying pollutants than other carnivores in the country. This paper reports on the concentrations of organochlorine residues and heavy metals (mercury, cadmium and lead) in a collection of polecat kidneys from Switzerland.

MATERIALS AND METHODS

Polecat carcasses were collected over the period 1983 - 1985 in Switzerland and adjoining areas of France (Weber 1988), where the species occurs in the lowland and the lower regions of the mountains. The most dramatic decline of polecat populations has occurred in the lowland region between the mountain chains of the Jura and the Alps. Human population density in the Swiss lowland is about 800 individuals per km^2. Industry is not only concentrated in the larger urban areas, but also distributed in numerous small towns and villages spread over the whole area. Agriculture in the lowlands is mainly arable farming. Rubbish incinerators are spread over the country and sewage sludge is deposited on arable land. The lower parts of the mountains consist mainly of forests, meadows and pastures. Human population density is low (about 30 persons per km^2)

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concentrating in the bottom of valleys where industry is also concentrated. The main wind direction is from (south-) west to (north-) east. An overview of chemical pollution in Switzerland is given in Biedermann et al. (1984).

Detailed information on polecat carcasses is given in Weber (1987, 1988). Most were road casualties. Carcasses were mainly aged by counts of tooth cementum annuli (Weber, 1989b), but in some cases tooth wear and skull ossification were used, which sometimes leads to uncertain ageing, only minimum ages being defined.

Kidneys were stored deep frozen in glass vials prior to analysis. Methods of organochlorine analysis largely followed FAO (1983). Tissue was thinly sliced and weighed. The tissue was stirred in 10ml acetone:hexane (35:10) and homogenized. The supernatant was decanted into a sintered glass funnel and the filtrate was collected into a separating funnel containing 20ml NaCl/phosphate (11.7g NaCl in 1l 0.1 M orthophosphoric acid), while sediment was resuspended in two further 10 ml aliquots of hexane:diethyl ether (9:1) and decanted after 5 min. The separating funnel was shaken and the aqueous phase was decanted and re-extracted in hexane. The solvent phase extracts were evaporated at 70^0C to dryness and the weight determined. The extract was re-dissolved in toluene and pesticides determined with a Carlo-Erba 4300 gas chromatograph, with a tritium electron capture detector and using a capillary column. The detection level was 0.01mg kg^{-1}.

For the analysis of metals approximately 0.5g samples of kidney were digested in 4 ml of a 4:1 (v/v) nitric and perchloric acid mixture. Initial digestion was at room temperature for 36-48 h, followed by careful heating at a temperature of 40^0C for 1h, to prevent frothing, after which the temperature was raised to 140^0C for a final 60-90 min. Samples were then allowed to cool and final solutions were made up to 10 ml with double distilled water. They were stored cool and analyzed within one week. Total mercury in samples was measured by flameless atomic absorption. Cadmium and lead were measured using a double beam atomic absorption spectrophotometer (AA 1275/ GTA 95) with correction for non atomic absorption by use of a deuterium lamp. A mean of three readings on each sample was recorded and this was within +95% CL. Detection limits were 0.1 ug kg^{-1} for mercury, 0.001 mg kg^{-1} for cadmium and 0.005 mg kg^{-1} for lead.

RESULTS AND DISCUSSION

Kidneys from a total of 80 animals (48 males, 31 females, one undetermined) were analyzed. Thirty-one animals were aged as juveniles, 15 as subadults and 30 as adults, with 4 of undetermined age. The distribution of sites from which polecats were obtained is shown in Fig.1. Four additional animals, not shown on the map, came from the Jura of France, immediately to the west of the area shown in Fig.1.

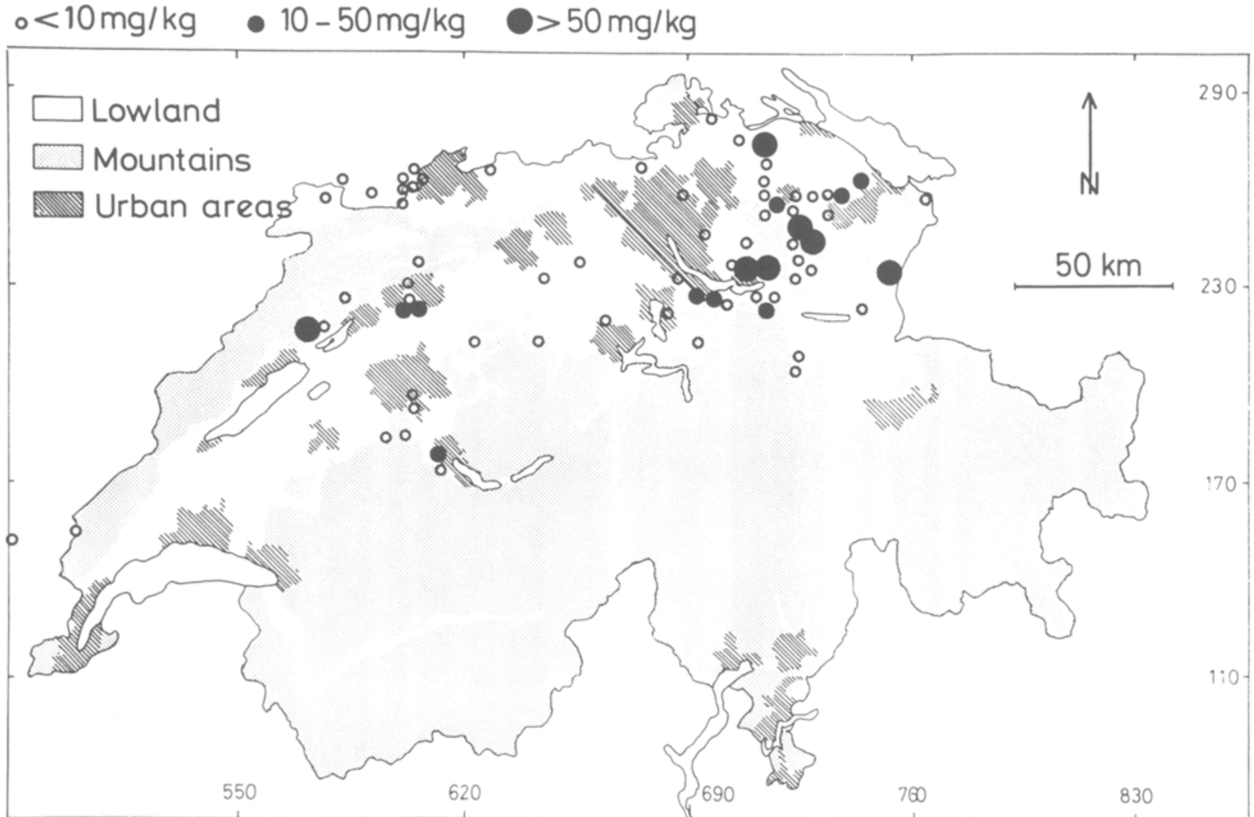

Fig. 1. The study area in Switzerland showing localities from which polecats were obtained and concentration ranges (mg kg^{-1} fat) of PCBs in kidneys of individuals.

The results of the analyses are summarized in Table 1. Lindane and DDE were ubiquitous, but at low concentrations. Dieldrin was present in only 39% of samples, again at low concentrations. Because of the generally small amounts of residues present in the samples, a more detailed statistical analysis of organochlorine pesticides was not made.

PCBs (determined against an Aroclor 1260 standard) were present in all samples, with a maximum concentration of 120.8 mg kg^{-1} lipid in an adult male. The distribution of PCBs, in three concentration ranges, is shown in Fig.1. Concentrations of PCBs greater than 50 mg kg^{-1} in muscle tissue are known to be associated with reproductive impairment in a related mustelid, the mink (*Mustela vison*) (Jensen et al. 1977). Concentrations greater than 50 mg kg^{-1} lipid occurred in kidney tissue of 7 (8.9%) of the polecats, while 12 (14.2%) had concentrations in the range 10-50 mg kg^{-1} lipid. The majority of polecats with elevated levels of PCBs were from the northeast of the country (Fig.1).

Mean concentrations of PCBs in males (14.6 mg kg^{-1} lipid) and females (12.2 mg kg^{-1} lipid) were not significantly different ($d = 0.43$, $P > 0.05$). However, significantly more males (15.9%) than females (6.5%) had concentrations of PCBs in kidneys greater than 20 mg kg^{-1} lipid ($G = 4.97$, $P < 0.05$). The mean concentration in juveniles (9.76 mg kg^{-1} lipid) was lower than that of subadults (14.89 mg kg^{-1} lipid) and adults (16.89 mg kg^{-1} lipid), but the difference in mean concentrations between the three age classes was not significant ($F = 0.71$, $P > 0.05$). However, 78 of the polecats were accurately aged to month (Weber 1989b). Mean PCB concentrations in males aged 12 months or over (18.4 mg kg^{-1}) were higher than in males less than 12 months (12.1 mg kg^{-1}), but the difference was not significant ($t=0.84$, $P> 0.05$). Conversely, mean PCB levels in females aged 12 months or over (4.8 mg kg^{-1}) was three times less than in females younger than 12 months (14.8 mg kg^{-1}), but again the difference was not significant ($t=1.8$, $P> 0.05$). Mean concentrations in males and females younger than 12 months were not significantly different ($t=0.37$, $P> 0.05$), but males of 12 months or older had significantly greater mean PCB concentration than females in the same age group ($t=2.34$, $P< 0.05$). There was no significant relationship between body weight and PCB concentration in kidneys ($r = 0.13$, $P> 0.05$).

Heavy metal concentrations were generally low. Mercury was present in all samples and cadmium and lead were detected in the majority. The highest concentration of mercury (5.45 mg kg^{-1} wet weight) was from an adult female from the northeast of the country, as were four out of five other animals with concentrations of mercury greater than 2 mg kg^{-1} wet weight. Mean concentrations of mercury in kidneys of males (1.05 mg kg^{-1}) and females (1.14 mg kg^{-1}) were not significantly different ($d = 0.31$, $P > 0.05$). The mean concentration of mercury in juveniles (0.76 mg kg^{-1}) was significantly lower than that of subadults

Table 1. Concentrations (means, ranges and percent contaminated) of organochlorine residues (mg kg^{-1} lipid) and heavy metals (mg kg^{-1} wet weight) in kidneys of polecat (n=80).

Compound	Mean	Range	% contaminated
lindane	0.94	.03 - 15.76	100
dieldrin	0.32	nd - 1.34	39
DDE	1.40	0.07 - 15.26	100
PCBs	13.50	1.14 - 120.8	100
mercury	1.04	0.07 - 5.45	100
cadmium	0.11	nd - 0.36	95
lead	0.42	nd - 5.83	99

(1.16 mg kg^{-1}) and adults (1.33 mg kg^{-1}) ($F = 4.37$, $P < 0.05$). Mean concentrations of cadmium in kidneys of juveniles (0.069 mg kg^{-1}) were significantly lower than those of subadults (0.20 mg kg^{-1}) and adults (0.14 mg kg^{-1}) ($F = 10.23$, $P < 0.001$), but there was no relationship between lead concentration and age ($F = 0.20$, $P > 0.05$).

The polecat has become restricted in distribution in Switzerland over the last four decades, as it has over much of continental Europe (Weber 1988). Habitat destruction is often cited as the primary reason for this decline, though the precise requirements of the species and how these may be influenced by habitat modification are inadequately understood. The effects of biomagnifying pollutants could also be important, for polecats forage extensively in wetlands and, in Switzerland, semi-aquatic amphibians are the staple food (Weber 1989a). A more severe decline throughout much of Europe in populations of the otter (*Lutra lutra*), with a more exclusively aquatic diet, has been clearly linked to organochlorine contamination (Mason & Macdonald 1986). Switzerland has advanced agriculture in the lowlands and is highly industrialized, leading to contamination of aquatic ecosystems. For example, high concentrations of PCBs have been recorded in burbot (*Lota lota*) in Switzerland (Burgermeister et al. 1983), leading the authors to conclude that the entire aquatic ecosystem of the country is severely contaminated.

Experimental studies with mink have shown that impaired reproduction results when females are fed a diet containing PCB concentrations of 3.3 mg kg^{-1} food, equivalent to a daily dose of 1mg (Jensen et al. 1977). These animals were found to have accumulated PCBs to a concentration of 50 mg kg^{-1} in muscle fat over a 66 day period. Other studies have indicated that reproduction in mink is inhibited on a daily intake of 25ug, while reproductive output was lowered in long-term experiments on a daily intake of 2.5ug (den Boer 1983). Experimental work has suggested, however, that ferrets (M. p. furo) are more resistent to the effects of PCBs than mink, reproduction in ferrets being prevented on a daily diet containing PCBs at a concentration of 20 mg kg^{-1}, a level that was lethal to mink (Bleavins et al. 1980).

Concentrations of organochlorine pesticide residues in Swiss polecats were low. Mean levels were markedly lower, for example, than in a sample of otters from the British Isles (Mason et al., 1986a), and were similar to levels in otters from the Orkney Islands, off northern Scotland (Mason and Reynolds 1988). Concentrations of PCBs were elevated in a number of polecats, the majority of them from the northeast of Switzerland (Fig.1) close to or downwind of the industrial region of Zurich. The current absence of the otter from much of its former European range is correlated with centers of industry and prevailing winds (Macdonald, in press).

In view of the experiments on ferrets referred to above (Bleavins et al., 1980) and the apparent tolerance of ferrets, compared with mink, to PCBs, it is difficult to ascertain whether concentrations of PCBs greater than 50 mg kg^{-1} in lipid would be associated with adverse effects in wild polecats and could in part explain the decline of the species. It may, however, be significant that only one animal, out of seven with PCB concentrations greater than 50 mg kg^{-1} in kidney, was more than one year old, though animals greater than one year old made up 27% of the sample. Females aged 12 months or over had lower mean concentrations of PCBs than younger females, and significantly lower than males in the same age group. The most likely reason is that PCBs are transferred to the foetus via the placenta during pregnancy and to the young in milk during lactation (Bleavins et al. 1982).

Concentrations of mercury, cadmium and lead were generally low. Mean concentrations in polecat kidneys were, for example, much lower than in a sample of otter kidneys from the British Isles (Mason et al. 1986b) and are unlikely to be of toxicological significance. Hanko et al. (1970) reported that daily intakes of mercury of 5-7 mg kg^{-1} in chicken proved lethal to ferrets, but such concentrations are unlikely ever to be encountered by polecats in the wild.

The concentrations of organochlorine pesticide residues and heavy metals in this sample of polecats from Switzerland were low. However, a number of animals had elevated concentrations of PCBs, especially those close to or downwind of the city of Zurich. The relationship between PCBs and the decline of the polecat in Switzerland would be worthy of further study.

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