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Organochlorine Residues in Northeastern Alberta Otters

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The use of organochlorine pesticides in North America has for the most part been legislatively curtailed during the last decade, and North American production of polychlorinated biphenyls (PCB's) was stopped in the 1970's. However, monitoring of chemical residues in fish and wildlife indicates that these persistent compounds are still much in evidence throughout North America. Data on chemical residues in Alberta wildlife, particularly non-migratory species, is for the most part unknown.

Otters (Lutra canadensis) are consumers of fish, invertebrates, amphibians and small mammals cohabiting their aquatic habitat (Gilbert and Nancekivell 1982). As carnivores at the terminus of their respective food chains, semi-aquatic mammals such as otter and mink (Mustela vison) may be expected to accumulate pesticides, PCBs and heavy metals. Otters are relatively sedentary and monitoring of chemical residues in their tissues might yield a diverse contaminant profile unique to the specific environs from which the animals are collected. Mercury residues in otters from Manitoba revealed that, through biomagnification otters accumulated about ten times more mercury than the concentrations detected in fishes from the same aquatic system (Kucera 1983). Consequently, furbearers may serve an indicator role in evaluating chemical residues. The purpose of this report is to present chemical residue data for otters collected from aquatic habitats in northeastern Alberta.

MATERIALS AND METHODS

Otter carcasses were obtained from licenced Alberta trappers during the trapping seasons of 1980-81 to 1982-83. The majority of the 158 carcasses submitted came from traplines in remote, forested areas in northeastern Alberta (Figure 1) and were trapped in both stream and lake associated habitats. Carcasses were kept frozen at -20°C or lower until dissected.

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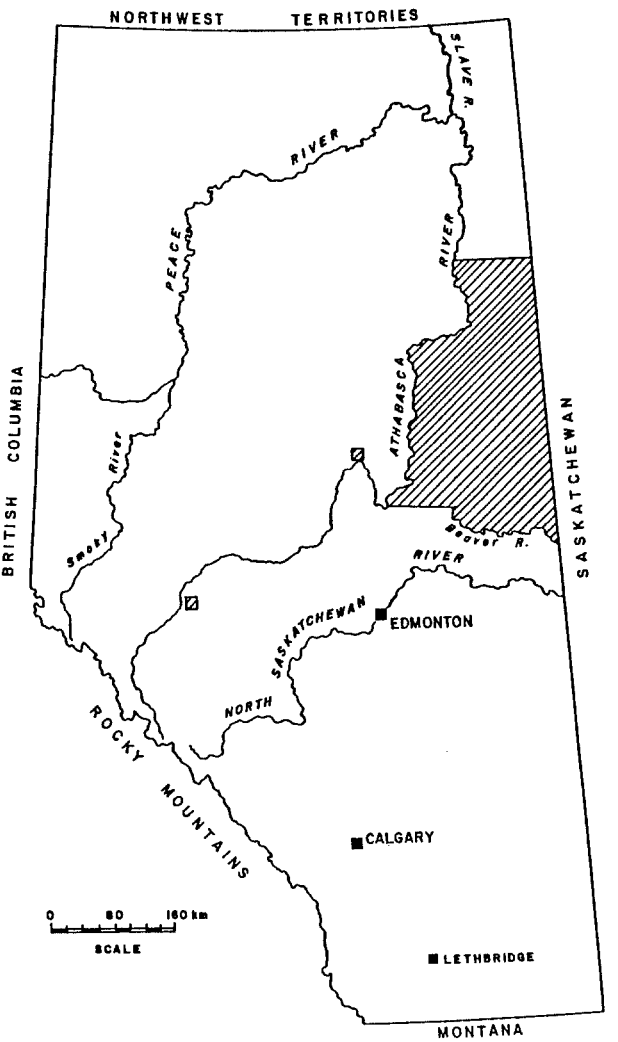

Figure 1. Otter collection areas in Alberta, Canada.

Fifty-eight (58) otter lipid samples of 1-5 g each were removed on dissection of the otter carcasses, wrapped in aluminum foil and stored at -20°C. Insufficient quantities of lipid tissue (abdominal or xiphoid) were present in some otter carcasses, consequently liver from 88 otters was selected for residue analysis. Individual 12-15 g portions of liver from each of 88 otters were paired to form 44 pooled samples. Pooling was selected because analysis of individual lipid tissues indicated that residue concentrations were low, hence pooling would decrease analytical costs but increase the overall number of carcasses analyzed. Pooling was done by selecting and pairing of livers from otters of the same age, sex and trapping location. Pooled samples of about 25-30 g total mass were wrapped in aluminum foil and stored at -20°C.

Table 1. List of chemical residues monitored in this study.

HCB (hexachlorobenzene)
α, ß, γ-BHC (hexachlorocyclohexane, or BHC)
Heptachlor
Heptachlor epoxide (HE)
Chlordane (cis) (oxy)
Aldrin
Dieldrin
Endrin
p, p´ DDT, p, p´ DDE, p, p´ DDD
Mirex
Pentachlorobenzene
Toxaphene
Methoxychlor
Aroclor 1242, 1254, 1260 (PCB)
[a]Polybrominated Biphenyls (PBB)

[a]Specific PBB's were not determined; PBB's were determined as a group.

Extraction, cleanup and analysis of pesticide and PCB residues in otter lipid and liver samples used the analytical procedures previously described for the analysis of fish lipid and muscle tissues (AEC 1984). Quantification of pesticides in µg/g (ppm) involved comparison with the respective pesticide standard, and PCB residues were calculated by comparison with Aroclor 1254 or 1260 standard. Detection limits based on 25 g samples were 0.001 µg/g for organochlorine pesticides and 0.002 µg/g for PCB's with recovery rates based on fortified otter liver > 80% for all compounds.

RESULTS AND DISCUSSION

Overall, the concentration of organochlorine pesticide and PCB residues detected in otter tissues were generally low and probably biologically insignificant (Table 2). This is not surprising in that the use of organochlorine pesticides for agricultural purposes would be low in this heavily forested northeastern Alberta region compared to intensely farmed or industrially developed parts of the country. For example, Proulx *et al*. (1985) reported maximal PCB residues of 117 ppm (lipid basis) in body homogenates of mink collected from southern Ontario habitats. In contrast, the low PCB and DDE residues detected in this study suggested that otters in northeastern Alberta inhabit a relatively non-contaminated environment. Although otter tissues were screened for 22 different compounds only HCB, α-BHC, DDE and PCB's were detected in lipid samples (Table 2). DDD, HE, oxy- and cis-chlordane and dieldrin were also detected at very low concentrations in otter liver samples.

Generally, all compounds ranged from ND (non-detectable) to 0.1 μg/g in otter lipid, and from ND to 0.01 μg/g in otter liver. Only PCB residues ranging from ND-2.34 μg/g in otter lipid and from ND to about 0.1 μg/g in otter liver (Table 2) consistently showed higher concentrations in the respective tissues. No difference in residues between the age or sex-class of otters was evident (Table 3). The presence of low concentrations of DDD, the chlordanes, HE and dieldrin reflect the catabolic function of the liver enzyme systems in degradation of pesticides compared to the storage function of lipid tissues. Although the concentrations in both tissue matrices were low, the lipophilic properties of HCB, α-BHC, DDE and PCB are evident on comparison of the residues in lipid and liver tissues (Table 3). Liver residue data were calculated on a wet weight basis, not on a lipid concentration basis.

Lindane (γ-BHC) is the only organochlorine insecticide that is still widely used in Alberta. About 52,000 kg of lindane were used in Alberta as a seed treatment or for the control of ectoparasites of cattle in 1980; however, the northeastern Alberta habitats where these otters were collected is totally non-agricultural. The α-BHC metabolite of lindane detected is most likely resultant of atmospheric fallout (Eisenreich et al. 1981), rather than the use of lindane as a pesticide in northeastern Alberta.

Similarily, air/precipitation-borne depositions to the habitats and food-chains of these northeastern Alberta otters could be the source of the HCB (hexachlorobenzene) residues detected in otter tissues. HCB is a petrochemical waste product, a contaminant in some pesticides, a fungicide, and also an intermediate breakdown product in lindane degradation. HCB is no longer registered as a fungicide in Canada; however, HCB is a persistent and bioaccumulating compound which is now recognized as a global pollutant. Although HCB can cause disorders in porphyrin metabolism of many species (Courtney 1979), the HCB residues detected in otter lipid in this study would be of no toxicological significance. Small quantities of HE detected in otter liver were perhaps metabolites of chlordane because the use of heptachlor in Canada was banned in 1969. Technical chlordane is a mixture of chlordane, cis (α) and trans (γ) isomers of chlordane, about 10% heptachlor and other compounds (McEwen and Stephensen 1979).

Although low in concentration and infrequent in occurrence, the presence of DDE residues in otter tissues many years after DDT use was banned suggests that the also banned but persistent PCB's will also require a long period for ecosystems to be free of this contaminant. Average PCB residues of about 0.4 μg/g as detected in these otter lipid samples were much lower than the residues detected by Mason et al. (1986) in British otters

TABLE 2. Range in concentration (μg/g wet weight)[a] of pesticides and PCB's in otter tissues.

Sex	Age[b]	Sample Size	HCB	α-BHC	DDE	DDD	Chlordane Oxy	Chlordane Cis	HE	Diel	PCB
Lipid Tissue											
M	SA	6	0.006-0.097	ND-0.038	ND-0.004	-	-	-	-	-	ND-1.370
	AD	25	0.009-0.038	ND-0.047	ND-0.040	-	-	-	-	-	Tr-1.390
F	SA	11	0.013-0.078	0.004-0.060	ND-0.158	-	-	-	-	-	ND-2.340
	AD	16	0.013-0.064	ND-0.054	ND-0.056	-	-	-	-	-	ND-0.331
Liver Tissue											
M	SA	6	0.001-0.005	Tr-0.001	Tr-0.004	-	Tr-0.003	-	ND-0.001	ND-Tr	Tr-0.036
	AD	14	0.001-0.020	Tr-0.001	ND-0.008	-	Tr-0.008	ND-0.002	Tr-0.001	ND-Tr	Tr-0.047
F	SA	10	0.001-0.004	Tr-0.002	ND-0.006	-	Tr-0.013	ND-0.006	ND-0.003	ND-0.001	ND-0.084
	AD	14	0.001-0.005	ND-0.002	ND-0.023	ND-0.005	ND-0.003	ND-0.001	ND-0.001	-	Tr-0.058

[a] ND and -, non-detected (<0.0005 μg/g); Tr, trace (<0.001 μg/g - 0.0005 μg/g>).
[b] SA, sub-adult; AD, adult

TABLE 3. Mean concentration (μg/g wet weight ± SD)[a] of pesticides and PCB's in otter tissues.

Sex	Age[b]	Sample Size	HCB	α-BHC	DDE	DDD	Chlordane Oxy	Chlordane Cis	HE	Diel	PCB
Lipid Tissue											
M	SA	6	0.036(0.032)	0.012(0.015)	0.001(0.002)	-	-	-	-	-	0.440(0.654)
	AD	25	0.025(0.007)	0.013(0.013)	0.006(0.012)	-	-	-	-	-	0.503(0.438)
F	SA	11	0.031(0.022)	0.032(0.015)	0.020(0.047)	-	-	-	-	-	0.410(0.678)
	AD	16	0.030(0.018)	0.018(0.013)	0.006(0.014	-	-	-	-	-	0.151(0.122)
Liver Tissue											
M	SA	6	0.003(0.002)	0.001(0.003)	0.002(0.001)	-	0.001(0.001)	-	0.001(0.001)	Tr	0.0130(0.014)
	AD	14	0.004(0.005)	Tr	0.002(0.002)	-	0.002(0.002)	Tr	0.001(-)	Tr	0.023(0.014)
F	SA	10	0.002(0.001)	0.001(0.001)	0.002(0.002)	-	0.002(0.004)	Tr	Tr	Tr	0.0180(0.025)
	AD	14	0.003(0.001)	Tr	0.003(0.006)	-	0.001(0.001	Tr	Tr	-	0.0120(0.014)

[a]-, non-detected (<0.0005 μg/g); Tr, trace (<0.001 μg/g - 0.0005 μg/g>); SD in parentheses.
[b]SA, sub-adult; AD, adult

(Lutra lutra) and would not influence the health or reproduction of these northeastern Alberta otters. For example, although PCB tissue residues were not reported, Aulerich and Ringer (1977) found that the health and reproduction of mink was not impaired during an 8-month controlled feeding trial until dietary PCB levels exceeded 2 ppm. Jensen et al. (1977) found that lipid residues of 14 ppm PCB had no effect on reproduction of female mink. Thus it appears unlikely that otter lipid residues <0.5 µg/g would impact on the health and reproductive status of otters.

The PCB residue concentrations detected in this study were low and probably biologically insignificant; however, the chemical composition of PCB isomers is important. Packed, rather than capillary chromatographic columns, or GC/MS instrumentation was used for identification of PCB residues in this study, thus identification of specific isomers was not possible. However, analysis of otter lipid yielded only 6 major PCB isomer peaks, while the Aroclor 1260 standard contained 13 peaks in the profile. Furthermore, the same methodology for fish muscle tissue analyzed by the Alberta Environmental Centre in recent years (AEC 1984) and reported by Somers (1985) routinely contains up to 13 definitive PCB isomer peaks.

Although PCB-metabolizing capability exists in fish, the activity of PCB metabolism appears to be relatively low (Safe 1984). Thus, the lack of specific PCB isomers in otter tissues reported in this study, compared to fish lipid/muscle PCB residues, suggests that fish-eating furbearers may be consuming and metabolizing potentially toxic PCB isomers or related compounds (eg. dibenzofurans) that fish are unable to transform, or slow at transforming to a less toxic state. The type of PCB's in the food chain of these otters could have been different than that of fish monitored elsewhere in Alberta. There is increasing evidence (Aulerich and Ringer 1979; Hornshaw et al. 1983; Aulerich et al. 1986), however, indicating that secondary toxicity of PCB's (eg. residues metabolized by fish) may be more toxic to vulnerable mammalian carnivores than technical mixtures.

This report suggests that the otters in northeastern Alberta are virtually free of organochlorine pesticide or PCB residues. Future emphasis for monitoring of chemical residues in carnivorous mammals should emphasize the identification of PCB isomers; but only if the total PCB residue concentrations are high. Secondly, future monitoring of residues in carnivorous mammals should probably be limited to the areas of intensive agricultural production in Alberta.

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REFERENCES

Alberta Environmental Centre (1984) Pesticide and PCB levels in fish from Alberta (Canada). Chemosphere 13:19-32

Aulerich RJ, Ringer RK (1977) Current status of PCB toxicity to mink, and effect on their reproduction. Arch Environ Contam Toxicol 6:279-292

Aulerich RJ, Ringer RK (1979) Toxic effects of dietary polybrominated biphenyls on mink. Arch Environ Contam Toxicol 8:487-498

Aulerich RJ, Ringer RK, Safronoff J (1986) Assessment of primary vs. secondary toxicity of Aroclor 1254 to mink. Arch Environ Contam Toxicol 15:393-399

Courtney KD (1979) Hexachlorobenzene (HCB): A Review. Environ Res 20:225-266

Eisenreich SJ, Looney BB, Thornton JD (1981) Airborne organic contaminants in the Great Lakes ecosystem. Environ Sci and Technol 15:30-38

Gilbert FF, Nancekivell EG (1982) Food habits of mink (Mustela vison) and otter (Lutra canadensis) in north-eastern Alberta. Can J Zool 60:1282-1288

Hornshaw TC, Aulerich RJ, Johnson HE (1983) Feeding Great Lakes fish to mink: Effects on mink and accumulation and elimination of PCB's by mink. J Toxicol Environ Health 11:993-946

Jensen S, Kihlstrom JE, Olsson M, Lundberg C, Orberg J (1977) Effects of PCB and DDT on mink (Mustela vison) during the reproductive season. Ambio 6:239

Kucera E (1983) Mink and otter as indicators of mercury in Manitoba waters. Can J Zool 61:2250-2256

Mason CF, Ford TC, Last NI (1986) Organochlorine residues in British otters. Bull Environ Contam Toxicol 36:656-661

McEwen FL, Stephenson GR (1979) The use and significance of pesticides in the environment. John Wiley and Sons Inc., Toronto, Ontario

Proulx G, Weseloh DVC, Elliott JE, Teeple S, Anghern PAM, Mineau P (1985) Organochlorine and PCB residues in Great Lakes mink populations. Can Wildl Service Report, CCIW, Burlington Ontario

Safe S (1984) Polychlorinated biphenyls (PCB's) and polybrominated biphenyls (PBB's): Biochemistry, toxicology, and mechanism of action. CRC Critical Rev in Toxicol 13:319-395.

Somers J.D. (1985) Pesticide and PCB residues in northeastern Alberta otter. AECV85-R4, Vegreville, Alberta, Canada, 35 p.

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