POLLUTION TRENDS IN RIVER OTTER IN GEORGIA

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Abstract: Eighty-one river otter *(Lutra canadensis)* carcasses were collected from trappers and a fur dealer in Georgia during the 1979 - 80 and 1980 - 81 trapping seasons for environmental pollutant analysis. Mercury occurred in all muscle, liver, and hair samples analyzed with ranges of 0.2 to 13, 1.2 to 60, and 7.1 to 155 ppm, respectively. Detectable cesium-137 occurred in 77% of the samples ranging from less than 141 to 6,660 pCi/kg. DDT and its metabolites were detected in 97% of the otter fat samples at levels ranging from 0.08 to 91.90 ppm. Mirex, dieldrin, and PCBs were found in 68, 59, and 66% of the samples with ranges of 0.16 to 75.40, 0.03 to 1.26, and 0.57 to 84.20 ppm. Muscle, hair, and liver mercury levels, cesium-137 and mirex levels were all significantly higher in the coastal plain than in the piedmont region of Georgia. Dieldrin, PCBs, and coastal plain muscle mercury were all significantly higher in the current study than in a similar study conducted during the 1976 - 77 trapping season whereas cesium-137 and DDD were significantly lower.

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One of the 1st instances of environmental pollution being recognized as a biological hazard occurred in the 1950's when yellow buntings *(Emberiza citrinella)* in Sweden were found dying of mercury poisoning after consuming mercury treated seed (Nelson et al. 1971). Although many toxic chemicals such as DDT and dieldrin have since been banned for usage, others such as mercury and PCBs are still released into the environment (Jenkins 1981, Ross et al. 1981). Because of localized trends in contaminant levels of wildlife and because southeastern coastal plain soils increase the availability of mercury and other contaminants to organisms due to their low clay content and low cation exchange capacity (Jenkins and Fendley 1968, Nelson et al. 1971, Cumbie and Jenkins 1974), continued monitoring of these and other pollutants is mandated.

Halbrook (1978) measured pollutant levels in Georgia otters collected during the 1976 - 77 trapping season. Contaminants found included mercury, cesium-137, DDT and its metabolites, PCBs, mirex, and dieldrin. In the present study, otters collected during the 1979 - 80 and 1980 - 81 seasons were analyzed for environmental pollutants. The objectives of the present study were to examine the environmental trends of mercury, cesium-137, and various chlorinated hydrocarbons in Georgia by comparing pollutant concentrations in the 1979 - 80 and 1980 - 81 trapping season otters to those caught during the 1976 - 77 season. Otters are valuable indicators of pollutant levels since they occupy a high trophic position, therefore *reflecting contaminant levels in organisms lower on the aquatic food chain.*

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METHODS

Seven otter carcasses from the 1979 - 80 trapping season and 74 carcasses from the 1980 - 81 season were collected from trappers and a fur dealer in Georgia. Since the 1979 - 80 sample size was small, it was pooled with the 1980 - 81 data producing a sample size of 81 carcasses. Nineteen carcasses came from the lower piedmont (Barrow, Greene, Madison, Oglethorpe, and Taliaferro Counties), 47 came from the lower coastal plain (Ware County), and 7 came from the sandhills region (Twiggs and Wilkinson Counties). Eight otters were caught in the saltmarsh (Bryan and McIntosh Counties) which was treated as a separate physiographic unit.

Carcasses were stored in plastic bags and frozen until samples for analysis could be taken. After thawing, a 300 g sample of muscle tissue was removed from the hind legs and neck region, placed in plastic containers, and frozen for cesium-137 analysis. One gram each of liver and muscle tissue was stored frozen in plastic bags for mercury analysis. Hair samples, also for mercury analysis, were taken from feet and stored in coin envelopes. One gram of fat, for analysis of chlorinated hydrocarbons, was removed from the pelvic region and frozen in plastic bags.

Laboratory procedures were similar to those of Halbrook (1978). Muscle, liver, and hair samples were analyzed for mercury using flameless atomic absorption. Fats were analyzed for chlorinated hydrocarbons by gas chromatography, and muscle samples were analyzed for cesium-137 by gamma spectroscopy. The presence of mirex and PCBs (Aroclor 1260) in 3 otters was verified by gas chromatography-mass spectroscopy. Certain procedures used in the current study deviate from those used by Halbrook (1978), however, in that a Perkin-Elmer 280 Atomic Absorption Spectrophotometer was used in the mercury analysis. In this study, Soxhlet extraction was performed on the fat samples before the gel permutation chromatography procedure in the chlorinated hydrocarbon analysis. In addition, muscle samples for cesium-137 analysis were packed into plastic containers and counted for 100 rather than 40 minutes. Heavy metal and pesticide residue analyses were performed at the Extension Poultry Science Laboratory, and the cesium-137 analysis was done at the School of Forest Resources, University of Georgia.

Statistical procedures used included analysis of variance comparing means between physiographic provinces and between the 2 studies, correlation analysis of muscle and hair mercury levels, and Duncan's multiple range test. Analysis of variance was performed after the data were transformed by $\log_e x$ to approximate a normal distribution. Unless otherwise stated, statistical significance is considered to be the $P < 0.05$ level.

RESULTS AND DISCUSSION

Mercury

Mercury levels in muscle and hair samples were highly correlated ($P < 0.01$) between otters and levels in each were significantly different among physiographic regions (Table 1). Mean muscle mercury levels were significantly lower ($P < 0.0001$) in the piedmont (1.77 ppm) than in the lower coastal plain (5.83 ppm). In coastal plain otter muscle and hair samples, mean mercury levels from the 1980 - 81 trapping season were found to be significantly higher ($P < 0.01$) than the levels reported by Halbrook (1978) in otters trapped during the 1976 - 77 season (Table 2). Muscle mercury levels from the lower coastal plain were 4.13 and 5.83 ppm from the 1976 - 77 and the 1980 - 81 studies, respectively. Piedmont hair samples contained significantly higher mean levels of mercury in the 1980 - 81 study (27.50 ppm) compared to the 1976 - 77 study (13.71 ppm), whereas muscle mercury levels were not significantly different in the 2 studies.

From the above data, it appears that mercury levels, particularly in the lower coastal plain, increased from 1976 - 77 to 1980 - 81. However, due to the dry weather experienced prior to and during the 1980 - 81 trapping season, very little open water was left in the lower coastal plain except in deep river swamps. Mercury uptake in otters may have been enhanced by the high acidities in these habitats (Nelson et al. 1971), possibly biasing mercury levels during this time period.

Mean mercury levels found in muscle tissue from coastal plain otters were more than 10 times the Environmental Protection Agency (EPA) limit for human food consumption of 0.5 ppm. Two individual otters contained 13 ppm of mercury in muscle tissue. In studies on mink *(Mustela vison)*, a species related to the river otter, Wobeser and Swift (1976), Wobeser et al. (1976), and Aulerich et al. (1974) found muscle mercury levels of 15.2, 16.0, and 25.2 ppm, respectively, to be lethal. The highest muscle mercury levels found in otters in the current study approach these lethal levels for mink.

Cesium-137

As with mercury, cesium-137 levels in otters varied with physiographic region. Coastal plain otter mean cesium-137 levels were 2833 pCi/kg compared to 141 pCi/kg for those in the piedmont (Table 3). Cesium-137 concentrations were significantly lower ($P < 0.01$) *in otters trapped in 1980 - 81 than in those trapped* during the 1976 - 77 season in both the piedmont and the coastal plain. Mean cesium-137 levels in piedmont otters were 759 pCi/kg in the 1976 - 77 study and less than 141 pCi/kg in 1980 - 81. In the coastal plain, levels were 5318 and 2833 pCi/kg in the 1976 - 77 and in the 1980 - 81 studies, respectively (Table 4). This decline in cesium-137 levels is consistent with other data from this laboratory.

Cesium-137 is one of the most important of the radionuclide byproducts from nuclear testing due to its abundance and slow rate of decay (Shannon 1965). Decreasing concentrations of cesium-137 in river otters is not surprising since most atmospheric nuclear testing took place in the 1950's (Langham and Anderson 1959). It appears that cesium-137 in the environment is diminishing due to its

Table 1. Muscle and hair mercury levels in 1980 - 81 trapping season otters in Georgia by physiographic region.

Physiographic region	Muscle, ppm			Hair, ppm		
	N	$\overline{X}^a$	Range	N	$\overline{X}^a$	Range
Coastal plain	47	5.83A	0.2 - 13	47	67.50A	7.1 - 155
Sandhills	7	5.01A	2.0 - 7.2	7	56.29AB	25 - 80
Saltmarsh	8	3.75AB	0.8 - 6.4	8	41.25BC	12 - 73
Piedmont	15	1.77B	0.6 - 3.3	12	27.50C	15 - 41

[a] Means not followed by the same letter are significantly different ($P < 0.05$).

Table 2. Mean muscle and hair mercury levels in Georgia piedmont and coastal plain otters caught during the 1980 - 81 trapping season compared to those caught in 1976 - 77.

Physiographic region	Muscle, ppm			Hair, ppm		
and sampling period	N	$\overline{X}$[a]	Range	N	$\overline{X}$[a]	Range
Piedmont 1980 - 81	15	1.77A	0.6 - 3.3	12	27.50A	15 - 41
Piedmont 1976 - 77	34	1.54A	0.8 - 5.1	34	13.71B	3.7 - 31
Coastal plain 1980 - 81	47	5.83A	0.2 - 13	47	67.50A	7.1 - 155
Coastal plain 1976 - 77	94	4.13B	0.13 - 10	92	24.11B	0 - 54

[a] Means within region followed by the same letter are significantly different ($P < 0.05$).

Table 3. Cesium levels in Georgia otters caught during the 1980 - 81 trapping season by physiographic region.

	Muscle cesium, pCi/kg[a]		
Physiographic region	N	$\overline{X}$[b]	Range
Coastal plain	47	2833A	<141 - 6660
Saltmarsh	8	298B	<141 - 622
Sandhills	7	148B	<141 - 181
Piedmont[c]	19	<141B	

[a] Detectability limit is 141 pCi/kg.
[b] Means not followed by the same letter are significantly different ($P < 0.05$).
[c] All values below the detection limit.

Table 4. Cesium levels in Georgia piedmont and coastal plain otters caught during the 1980 - 81 trapping season compared to those caught in 1976 - 77.

Physiographic region	Muscle cesium, pCi/kg[a]		
and sampling period	N	$\overline{X}$[b]	Range
Piedmont 1980 - 81	19	< 141A[c]	
Piedmont 1976 - 77	34	759B	<141 - 2628
Coastal plain 1980 - 81	47	2833A	<141 - 6660
Coastal plain 1976 - 77	94	5318B	<141 - 21219

[a] Detectability limit is 141 pCi/kg.
[b] Means within region not followed by the same letter are significantly different ($P < 0.05$).
[c] All values below the detection limit.

removal from biological circulation by its fixation in soil clays and due to physical radioactive decay (Dahlman et al. 1975).

DDT and Metabolites

DDE was the most commonly found organochlorine pesticide in otter fats, occurring in 97% of the samples analyzed. Mean DDE and DDT levels were 6.06 and 0.04 ppm respectively (Table 5). One otter from Twiggs County contained 91.90 ppm DDE. Neither DDE or DDT levels were significantly different from those found in the 1976 - 77 study. However, DDD levels in the 1976 - 77 study (0.34 ppm) were significantly higher than the 1980 - 81 levels (0.07 ppm).

Table 5. Residues of DDT and its metabolites in otters caught during the 1980 - 81 trapping season compared to those caught in 1976 - 77[a].

	p, p-DDT, ppm[b]		p, p-DDD, ppm[b]		p, p-DDE, ppm[b]	
	1980-81	1976-77	1980-81	1976-77	1980-81	1976-77
N	70	107	70	107	70	107
% Positive	1	7	11	43	97	95
$\bar{X}^c$	0.04A	0.14A	0.07B	0.34C	6.06D	10.58D
Range	0-2.94	0-2.28	0-1.47	0-6.98	0-91.90	0-91.41

[a] No residues of the following pesticides were detected at the detection limit indicated: aldrin (< 0.01 ppm), BHC (< 0.01 ppm), carbophenoethion (< 0.10 ppm), chlorodane (< 0.10 ppm), diazinon (< 0.10 ppm), endrin (< 0.02 ppm), ethion (< 0.10 ppm), lindane (< 0.01 ppm), malathion (< 0.10 ppm), methoxychlor (< 0.05 ppm), parathion (< 0.05 ppm), rabon (< 0.10 ppm), and toxaphene (< 0.01 ppm). Six samples of heptachlor epoxide were above the detection limit (< 0.02 ppm), 2 samples of methyl parathion were above the detection limit (< 0.10 ppm), and 1 sample of heptachlor was above the detection limit (< 0.01 ppm).

[b] Residue levels below detection limits were given a value of 0.

[c] Means not followed by the same letter are significantly different ($P < 0.05$).

The data presented here indicate a downward trend in environmental levels of DDT and its metabolites, especially DDD. This is consistent with the findings of other recent pollutant monitoring studies on shorebirds (Blus and Lamont 1979), bald eagles *(Haliaeetus leucocephalus)* (Kaiser et al. 1980), fish (Ludke and Schmitt 1980), and black duck *(Anas rubripes)* eggs (Haseltine et al. 1980), which indicate overall declines in DDT.

Gilbert (1969) reported decreased reproductive capability in mink given rations containing 0.58 and 0.42 ppm DDE. Test females experienced an in utero loss of 1.8 kits per female compared to 0.6 kits per control female. DDE levels in adipose tissue of the experimental mink ranged from 3.68 to 12.30 ppm. The concentrations of DDE found in river otters were within and above the range reported to impair reproduction in mink.

Mirex

Mirex residues were significantly lower ($P < 0.01$) in the piedmont than in the coastal plain (Table 6). Mirex levels in river otters collected during 1980 - 81 were detectable in 87% of the coastal plain samples with a mean of 13.41 ppm and were detectable in 24% of the piedmont samples with a mean of 0.44 ppm (Table 7). This is not significantly different from levels found by Halbrook (1978) in the 1976 - 77 study.

Table 6. Mirex levels in 1980 - 81 trapping season otters according to physiographic region.

		Mirex, ppm		
Physiographic region	N	% Positive	$\bar{X}$[a]	Range
Coastal plain	39	87	13.41A	0 - 75.40
Saltmarsh	8	100	5.30AB	0.73 - 12.90
Sandhills	6	67	3.79AB	0 - 16.62
Piedmont	17	24	0.44B	0 - 2.02

[a] Means not followed by the same letter are significantly different ($P < 0.05$).

Table 7. Residues of mirex in Georgia otters caught during the 1980 - 81 trapping season compared to those caught in 1976 - 77.

	Sampling	Mirex, ppm[a]			
Location	Period	N	% Positive	$\bar{X}$[b]	Range
Piedmont	1980-81	17	24	0.44A	0 - 2.02
	1976-77	20	5	0.56A	0 - 10.09
Coastal Plain	1980-81	39	87	13.41A	0 - 75.40
	1976-77	87	23	8.96A	0 - 168.95
Statewide	1980-81	70	68	8.50A	0 - 75.40
	1976-77	107	20	7.38A	0 - 168.95

[a] Residue levels below detection limits were given a value of 0.

[b] Means within region not followed by the same letter are significantly different ($P <$ 0.05.)

Residue levels in otter fats analyzed in these 2 studies indicate little change in environmental levels of mirex. This is contrasted by a study in which Holcomb and Parker (1979) monitored pond sliders *(Chrysemys scripta)* and box turtles *(Terrapene carolina)* in Mississippi from 1970 to 1977. A decline in mirex residues in these reptiles was reported following its ban. In the current study, and in a study by Baetcke et al. (1972) on Mississippi wildlife, mirex levels often exceeded levels of DDE. This is surprising since DDT was used for a longer period of time and at greater amounts than mirex.

Dieldrin

Mean dieldrin concentrations in otter adipose tissue were significantly higher ($P < 0.01$) in the current study (0.29 ppm) than in the 1976 - 77 samples (0.03 ppm). Dieldrin was found in 41 of the 70 samples from 1980 - 81 while it was found in only 9 of the 107 samples analyzed from 1976 - 77. From the data presented in the current study, it appears that environmental levels of dieldrin have increased from 1976 - 77 to 1980 - 81 although trace levels may be more subject to bias due to differences in analytical technique.

PCBs

No significant differences in PCB levels in otters due to physiographic location were detected. Concentrations were significantly higher in otters trapped during 1980 - 81 (8.08 ppm) than during the 1976 - 77 (4.23 ppm) season. In addition, PCBs were detectable in 66% of the 1980 - 81 otters compared to only 50% of the 1976 - 77 otters. The results of this study suggest that PCB levels in otters are not declining at this time.

In our study, 1 otter contained 84.20 ppm PCBs which closely approaches the levels known to cause decreased reproduction in mink (Jensen et al. 1977). Caution should be used however, before the results of experiments on mink are applied directly to river otters. Studies with ferrets *(Mustela putorius)* for instance, also a mustelid, indicate that they are not as susceptible to PCBs as mink (Bleavins et al. 1980).

The increase in mercury, dieldrin, and PCB residues in otters from the 1976 - 77 trapping season compared to those from 1980 - 81 may indicate increases of these pollutants in the environment although trends are difficult to assess after only 2 sampling periods. Possible non-point sources of mercury pollution in Georgia should further be investigated and the possibility of illegal dumping of organochlorines should not be overlooked. Many of the contaminants we found in river otters occurred at levels known to cause reproductive impairment in similar species. This situation needs continued research and evaluation, particularly in biomagnification prone physiographic provinces.

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