Bull. Environm. Contam. Toxicol. 27, 499-505 (1981)

Relationships between Brain and Carcass Organochlorine Residues in Ospreys

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Data on residues of various organochlorines in tissues of birds have been used to determine rates of sublethal exposure and to determine if individuals have died of lethal exposure. Sublethal exposure to organochlorines is best measured by residue concentrations in carcass, whereas diagnosing death by organochlorines is best determined by residue concentrations in brain (see HEINZ et al. 1979 for review). When the fat of birds becomes depleted, organochlorine residues are mobilized, resulting in their redistribution and increased concentrations in other tissues. Brain residues increase under such conditions and these increases have been related to reductions in carcass lipids (ECOBICHON and SASCHENBRECKER 1969, SODERGREN and ULFSTRAND 1972, STICKEL et al. 1973, BOGAN and NEWTON 1977, and others). A strong negative correlation between percent lipid in aliquots of osprey (Pandion haliaetus) carcasses and the brain-carcass ratio of DDE in these birds was previously reported (WIEMEYER et al. 1980); as lipid levels declined the brain-carcass ratio of DDE increased.

Organochlorine concentrations in brain and carcass of ospreys previously have been reported to document the levels of sublethal exposure and the cases of excessive exposure possibly causing death (WIEMEYER et al. 1975, 1980). We now report on additional relationships between certain organochlorine residues in brain on a wet weight basis and residues in carcass on a lipid weight basis.

METHODS

Data from 36 ospreys containing quantifiable levels of at least one of five given toxicants in both brain and carcass were used in the statistical analyses. These wild birds, found dead or moribund, died of a variety of causes and contained widely ranging amounts of fat. Data from 6 birds from Connecticut and Virginia in 1967-1970 (WIEMEYER et al. 1975), 21 of 26 birds from the Eastern United States for the years 1968-1973 reported by WIEMEYER et al. (1980), and 9 additional birds from the Eastern United States obtained since 1973 (WIEMEYER unpublished data) were included in the analyses reported on here. One outlying datum point for dieldrin from one bird was omitted because of a lack of agreement between duplicate chemical analyses. Data from one bird reported in WIEMEYER et al. (1980) were excluded because only one-half of the brain was analyzed.

0007-4861/81/0027-0499 $01.40

Methods of chemical analyses for samples collected through 1973 were described previously (WIEMEYER et al. 1975, 1980). Analytical methods for the nine birds collected since 1973 were as follows. A 10-g portion of the homogenized carcass (whole body less head, wings, feet, skin, liver and gastro-intestinal tract) and the entire brain were analyzed separately. The samples were mixed with anhydrous sodium sulfate, extracted 7 h with hexane in a Soxhlet apparatus and lipids removed by Florisil column chromatography. Pesticides and polychlorinated biphenyls (PCBs) were separated on a SilicAr column into three or four fractions. Procedures used were those described by CROMARTIE et al. (1975), except when four fractions rather than three were separated on the SilicAr column to insure the partition of dieldrin and endrin into an individual fraction (KAISER et al. 1980). The organochlorines in each fraction were identified and quantified with a gas chromatograph using an electron-capture detector and a 1.5% OV-17/1.95% QF-1 column. Average recoveries ranged from 80-104% in spiked avian tissues. Residues were not corrected on the basis of recoveries. The lower limit of reportable residues was 0.10 ppm for pesticides and 0.5 ppm for PCBs. Residues in three samples were confirmed with a Finnigan 4000 series gas chromatograph/mass spectrometer; operating conditions were described by KAISER et al. (1980).

Hexane was used in most lipid extractions, although petroleum ether was used for a few of the older samples. There were no appreciable differences in residue levels (ppm lipid) between hexane and petroleum ether extracts from two osprey carcasses from which two portions of each were analyzed using each extraction solvent. Only those PCB residues that were quantified by gas chromatography were included in the data analyses.

Residues in brain (expressed on a wet weight basis) and in carcass (expressed on a lipid weight basis) were converted to common logarithms. Simple regression equations using the log-transformed data were computed to determine the relationships between brain and carcass residue concentrations for five toxicants: DDE, DDD, dieldrin, heptachlor epoxide, and PCBs. Simultaneous 95% confidence intervals for slope and intercept were calculated for each contaminant using the Bonferroni method (NETER and WASSERMAN 1974). The 95% confidence band for each regression line was also determined (NETER and WASSERMAN 1974).

RESULTS AND DISCUSSION

Regression equations for deriving estimates of residues in brain on a wet weight basis from residues in carcass on a lipid weight basis are presented in Table 1. For each contaminant, the residue levels in brain were a function of the concentrations in the carcass for those birds in which quantifiable residues were found in both brain and carcass. These relationships for DDE and dieldrin are illustrated in Figure 1. More than 80% of the variation in estimated brain levels can be attributed to their linear regression on carcass

TABLE 1

Regression equations for estimating residues in brain on a wet weight basis (Y) from residues in carcass on a lipid weight basis (X) in ospreys.

Contaminant	N	Equation	R^2
p,p'-DDE	35	$\log_{10} Y = -2.161 + 1.051 \log_{10} X$	0.89
p,p'-DDD	23	$\log_{10} Y = -2.203 + 1.036 \log_{10} X$	0.81
Dieldrin	19	$\log_{10} Y = -1.626 + 0.904 \log_{10} X$	0.88
Heptachlor epoxide	5	$\log_{10} Y = -1.654 + 0.739 \log_{10} X$	0.99
PCBs	21	$\log_{10} Y = -1.657 + 0.844 \log_{10} X$	0.89

levels. The simultaneous 95% confidence intervals for slope and intercept for each contaminant overlapped those of all other contaminants (Table 2), therefore the regression equations for the various contaminants do not appear to be different. Statistical comparisons of slopes and intercepts cannot be made because the data were not obtained from independent samples of birds.

Lower levels of each of the five toxicants that were found in the brains (ppm wet weight) of birds that were experimentally killed were obtained from the literature (Table 3). Each value was multiplied by 0.8. These values were selected as representing levels at which birds would be entering a danger zone approaching lethality. These latter values were then used to determine the estimated lower levels in the carcass (ppm lipid weight) in ospreys at which birds would be approaching the danger zone, using the 95% confidence bands around the regression lines. When contaminant levels in the carcasses of ospreys exceed these values the brain should be analyzed to determine if the bird died of organochlorine poisoning. The regression equations can also be used for estimating the residue concentrations of given contaminants in the brain when only the carcass has been analyzed.

The technique of estimating brain residues from carcass residues was first reported by OHLENDORF et al. (1979) for dieldrin alone in several species of herons. This technique has also been used for bald eagles (Haliaeetus leucocephalus) (BARBEHENN and REICHEL, in press) and bats (CLARK 1981). Efforts should be made to apply this technique to species of birds that are frequently analyzed for organochlorines, especially if high brain residues are occasionally expected. Considerable savings in manpower, equipment, and materials could be realized by analyzing only

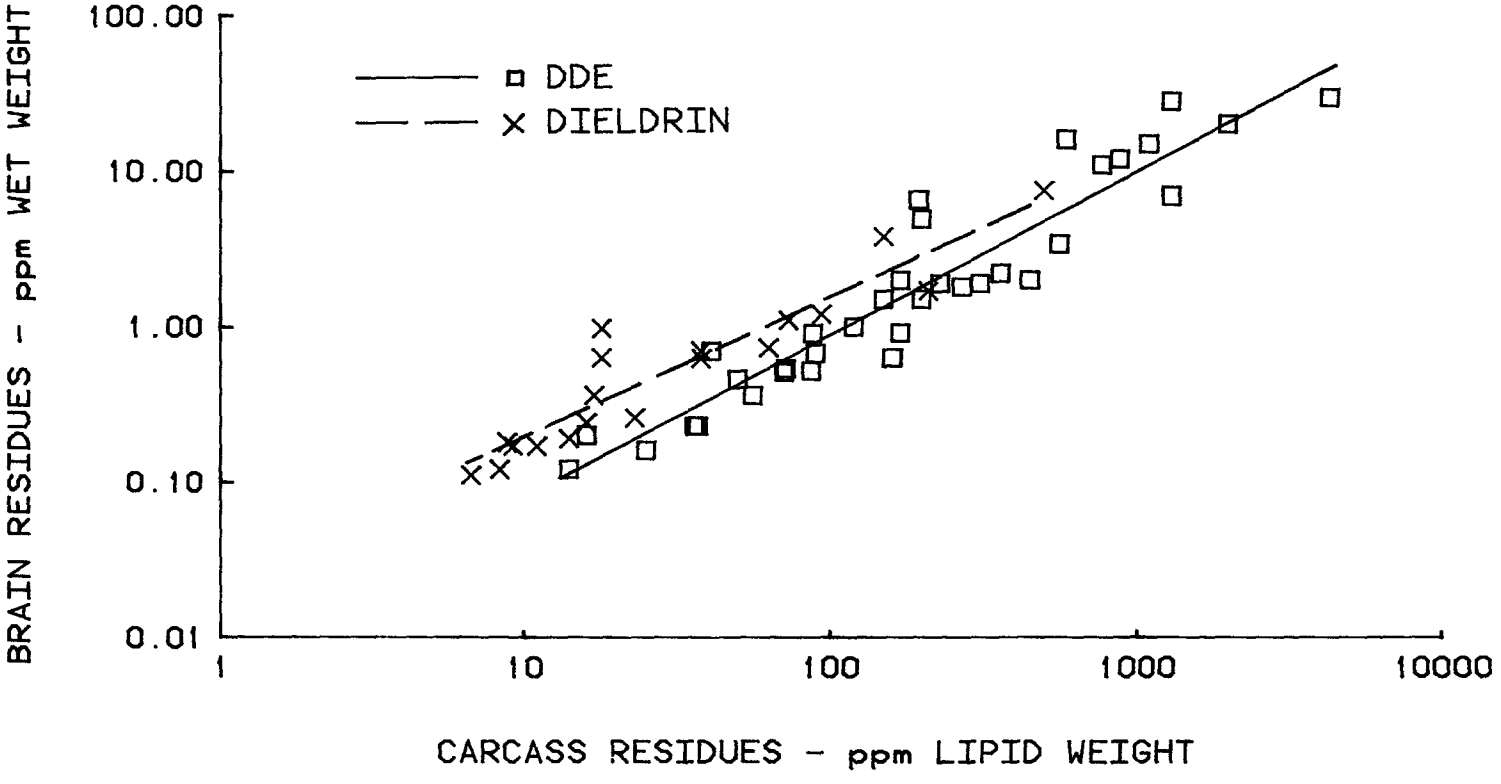

FIGURE 1. Regressions of DDE and dieldrin concentrations (ppm, wet weight) in the brains of ospreys on that in the carcass (ppm, lipid weight). See Table 1 for regression equations and R^2 values.

TABLE 2

Simultaneous 95% confidence intervals for model parameters.

Contaminant	Slope	Intercept
p,p'-DDE	0.901 to 1.201	-2.511 to -1.811
p,p'-DDD	0.773 to 1.299	-2.717 to -1.689
Dieldrin	0.707 to 1.101	-1.937 to -1.315
Heptachlor epoxide	0.539 to 0.939	-1.858 to -1.450
PCBs	0.679 to 1.009	-2.066 to -1.248

the carcass of birds, except where high brain residues are expected.

The range of residue concentrations in this series of ospreys seldom entered the lethal range. This method of estimating brain residues from carcass residues should be explored using data from various experimental series of birds where many were known to have died of neurotoxic poisoning from different toxicants to determine if there are any changes in the brain-carcass contaminant relationship within the lethal range of residues. The brain-carcass DDE relationships for two species of icterids were significantly different from one another (CLARK 1981), therefore the equations presented here should not be applied to other species. The equation for estimating PCBs in brain should be used with caution because of problems in chemically quantifying these residues.

ACKNOWLEDGEMENTS

We thank Christine M. Bunck and Timothy A. Grunwald for statistical advice and assistance, and E. H. Dustman and W. C. Eastin, Jr. for critical reviews of the manuscript.

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TABLE 3

Lower lethal levels of toxicants found in the brains (ppm wet weight) of experimentally poisoned birds and estimated levels in the carcasses (ppm lipid weight) of ospreys entering a lower danger zone with respect to lethality.

Toxicant	Lower Lethal Level in Brain	Source	80% of Lower Lethal Level in Brain (danger zone)	Lower Level in Osprey Carcass Estimated to Approach Lethal Danger Zone[a]
p,p'-DDE	250	STICKEL et al. 1970	200	9200
p,p'-DDD	86	STICKEL et al. 1970	69	2800
Dieldrin	4.0	STICKEL et al. 1969	3.2	140
Heptachlor epoxide	9.2	STICKEL et al. 1979	7.4	710
PCB	349	STICKEL et al. 1975	279	26000

[a] Levels calculated from 95% confidence bands about the regression equations (see text).

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Accepted July 14, 1981