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Organochlorine Pesticide and PCB Residues in Western Grebes from Bear River Migratory Bird Refuge, Utah

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The breeding biology of western grebe (Aechmophorus occidentalis) was studied at Bear River Migratory Bird Refuge (MBR), Utah in 1973 and 1974. As part of this study organochlorine pesticides and PCB's (polychlorinated biphenyls) were monitored in tissues and eggs of western grebes. Contaminant levels in fish, the primary food of western grebes, were also monitored. Contaminant concentration was correlated with the condition of the birds as determined by visceral fat content.

METHODS

Analyses of samples were made at the Denver Wildlife Research Center. Samples were prepared for analyses using the method of PETERSON et al. (1976). Analyses were made on a Varian Aerograph Model 2740 gas chromatograph under the following conditions: ^{3}H detector, inlet and column temperatures 215, 125, 190 C, respectively; column dimensions 2 m x 2 mm I.D., column packings of 3% OV-1 on 80/100 mesh Chromsorb W, AW, DMC 5, and 5% AF-1 on 100/200 mesh Chromsorb W, AW, DMC 5, and nitrogen carrier gas with a flow rate of 40/ml/min. Amounts of DDE and DDD present in samples were calculated by comparing sample peak heights with those of standards. Amounts of PCB 1260 and PCB 1254 were calculated by comparing peak areas of samples with those of standards.

RESULTS AND DISCUSSION

Breast muscle, visceral fat, blood, and whole eggs of western grebe were examined for organochlorine compounds. DDE, DDD, PCB 1260, and PCB 1254 were found in various concentrations in the four tissues examined (TABLE 1). Levels of contaminants had great variability in all tissues, and thus averages had limited value. KEITH (1969) also found great variability in pesticide content of western grebe at Tule Lake National Wildlife Refuge. DDE was the predominant contaminant found at Bear River Migratory Bird Refuge.

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TABLE 1

Contaminant levels in western grebe tissues collected at Bear River Migratory Bird Refuge in 1973 and 1974.

Tissue	n	Contaminant	Basis	$\bar{X}$	90% CI	Range
Breast muscle	24	DDE	wet	12.8	8.1	<0.1-115.2[a]
			lipid	513	280	3.3287
		DDD	wet	0.8	0.5	<0.1-6.0
			lipid	29	13	2-171
		PCB 1260	wet	3.8	2.1	ND-17.6[b]
		PCB 1254	wet	3.5	1.8	ND-17.6
Visceral fat	18	DDE	wet	61.5	23.0	5.4-213.0
		DDD	wet	5.2	2.0	0.5-16.4
		PCB 1260	wet	22.4	13.0	<1-147.1
		PCB 1254	wet	16.7	8.2	<1-84.0
Blood	16	DDE	wet	0.55	0.26	.04-2.00
		DDD	wet	0.07	0.04	ND-.20
		PCB 1260	wet	<1	--	ND-1.0
		PCB 1254	wet	<1	--	ND-1.1
Whole eggs	40	DDE	wet	6.6	1.6	1.0-21.4
			lipid	76.5	17.7	20-275
		DDD	wet	1.3	0.3	0.3-4.7
			lipid	14.9	3.1	3-52
		PCB 1260	wet	<1	--	<1-5.4
		PCB 1254	wet	<1	--	<1-3.8

ND = none detected, counted as 0 in averages
a = <0.1 ppm counted as 0.05 ppm in averages
b = <1.0 ppm counted as 0.5 ppm in averages

PCBs 1260 and 1254 were found in lower levels than DDE but higher levels than DDD. DUSTMAN et al. (1971) reviewed PCB contamination patterns and concluded that PCB levels of 10 or more ppm in eggs were high by present day standards and that populations having contamination at these levels should be investigated for population problems. By this standard, PCB contamination in western grebes at Bear River Migratory Bird Refuge appeard low (averages in eggs of PCB 1254 and 1260 were both < 1 ppm). Levels of DDTR (sum of DDT, DDE, and DDD) in eggs of western grebes

compared favorably with those seen in other studies of fish-eating birds (ANDERSON et al. 1969), GREICHUS et al. 1973, KNOPF and STREET 1974, KURY 1969, PRESST and JEFFERIES 1969, and RISEBROUGH et al. 1963). Several other studies, including one done on western grebes (RUDD and HERMAN 1972), have shown much higher contamination levels.

Levels of DDE and DDD encountered at Bear River Migratory Bird Refuge are much lower than those found in the studies conducted at Clear Lake, California (RUDD 1964, HERMAN et al. 1969, RUDD and HERMAN 1972). Western grebe eggs (n=17) collected in 1967 at Clear Lake averaged 145.1 ppm DDE and 298.7 ppm DDD. In 1969 DDE averaged 48 ppm and DDD 120 ppm in eggs (n=28) (all figures lipid basis) (RUDD and HERMAN 1972). Western grebe eggs (n=40) collected at Bear River MBR in 1973 and 1974 averaged 76.5 ppm DDE and 14.9 ppm DDD (lipid basis). RUDD and HERMAN (1972), on the basis of their Clear Lake study, concluded "Direct accumulation of residues in eggs followed by toxic manifestations as the yolk sac is absorbed in young birds are the presumed bases of hatchling mortality." Based on the above criteria, levels of DDE and DDD in western grebe eggs at Bear River MBR do not appear to be causing hatchling mortality. No indication of hatchling mortality was found in the nesting study and production of young as measured by brood counts.

No direct mortality from pesticide poisoning was documented at Bear River MBR. No residue levels in brain, the best indicator of mortality resulting from pesticides, were monitored. Much higher levels in breast muscle and fat have been seen in live western grebes from other areas (KEITH 1969, HERMAN et al. 1969). RUDD and HERMAN (1972) collected two western grebes at Clear Lake with 41.1 and 47.9 ppm DDD wet weight in brains, that they believe had died of pesticide poisoning. Levels of DDD in breast muscle for these same birds were 23.0 and 45.9 ppm wet weight. Both birds were emaciated and had brood patches. No levels of other contaminants were mentioned. Five emaciated dead western grebes from Bear River Migratory Bird Refuge had comparable levels of DDE in breast muscle with the DDD levels in the two birds from Clear Lake. Since brains were not examined and live birds with higher residue values have been collected, mortality cannot be attributed to pesticide poisoning. High levels in breast muscle do, however, suggest future consideration be given to residue analysis

of brain tissue from birds found dead at Bear River Migratory Bird Refuge.

Pesticide concentrations in blood, visceral fat, and breast muscle are related to the visceral fat content of the bird. Western grebes with sparse or no visceral fat have higher levels of DDE in breast muscle, blood, and fat than those birds with abundant visceral fat. Significantly different levels of DDD, PCB 1260 and PCB 1254 were found in birds with varying amounts of visceral fat (TABLE 2).

TABLE 2

Residue averages and Mann Whitney U values for differences between samples with sparse and no visceral fat and abundant visceral fat in western grebes from Bear River Migratory Bird Refuge.

	DDE	DDD	PCB 1260	PCB 1254
Visceral fat n=19				
$\bar{x}_a$ (ppm)	30.6	3.3	8.6	7.1
$\bar{x}_s$ (ppm)	83.9	6.7	32.5	23.6
U	19*	21*	19*	25
Breast muscle n=23				
$\bar{x}_a$ (ppm)	2.6	0.5	0.6	1.2
$\bar{x}_{s_n}$ (ppm)	19.2	3.0	19.3	12.5
U	17.5*	35	15.5*	31*

* indicates significance @ a=.05
a-abundant visceral fat
s-sparse visceral fat
sn-sparce or no visceral fat

The interaction of lipids and pesticides has been studied in the laboratory. FINDLAY and DEFRETAS (1971) introduced DDT into pigeons and then starved them. They found that DDT moved from fat into muscle but not into brain, liver, heart, or blood. They also found fatty acids to move out faster than DDT. ECOBICHON and SASCHENBREKER (1969) found that restriction of food to cockerels resulted in loss of lipids and increased levels of DDT in plasma, brain, liver, and heart. DONALDSON et al. (1968) found increased DDT levels in blood from starved chicks.

KEITH (1969) suggested that during stress periods of fast, DDT is mobilized from fat and transferred into other tissues. These stress conditions could exist for western grebes during migration, breeding, and periods of fast, starvation, or disease. HERMAN et al. (1969) kept western grebes in captivity with an unrestricted food supply. Even with unrestricted food, the grebes showed cyclic fluctuations in both feeding activity and weight. Western grebes also fast when nesting. One bird tends the nest and the other goes out to forage. Western grebes found dead usually contained sparse or no visceral fat and were assumed to have been subject to some stress, possibly disease or starvation. Some form of stress could account for the utilization of lipids and the subsequent transfer of contaminants to other tissues. The greater concentration of residues in sparse visceral fats could be explained by the more rapid movement of fatty acids than residues out of the lipid tissue, as suggested by FINDLAY and DEFRETAS (1971).

DDE residues in blood from western grebes with sparse or no visceral fat are significantly (t 2.13, $p < .05$) higher than levels of DDE in blood from birds with abundant visceral fat. Average DDE in blood from birds with abundant visceral fat ($n=4$) was 0.63 ppm and in birds with sparse visceral fat ($n=5$), 1.14 ppm. It appears that as lipids are utilized DDE is transferred from fat into blood. There is also a significant difference in DDE levels in blood between breeding and non-breeding western grebe. Four western grebes (3 females and 1 male) collected off the nest had significantly higher (t 5.5, $p < .05$) DDE levels in blood than nine non-breeding western grebe collected by shooting and drive banding. Average DDE for breeders was 0.65 ppm and for non-breeders 0.29 ppm (wet weight basis). The difference in DDE levels may be related to lipid metabolism. Breeding birds, attending the nest and fasting, could be metabolizing fat, and in the process, increasing DDE levels in the blood.

Fish, the primary food of western grebes, were sampled for pesticide and PCB residues. DDE was the only contaminant detected in the three fish species sampled at Bear River Migratory Bird Refuge. Samples consisted of five fish, of the same species and in the 7.5 to 11.5 cm size range, found together. DDE was found at 0.01 ppm in Cyprinus carpio, 0.02 ppm in Ictalurus melas, and 0.02 ppm in Gila atraria (wet weight basis). PCBs or DDD were not detected.

RISEBROUGH et al. (1968) have suggested that the ratio of total DDT to PCB may be useful in determining the location in which a bird has picked up contaminants. They found DDT to PCB ratios between one and two for United States west coast bay feeding birds. This same ratio was between 9 and 10 for birds collected in areas remote from PCB contamination. Western grebes collected at Bear River Migratory Bird Refuge had an average DDT to PCB ratios of 1.8 for breast muscle and 1.6 for visceral fat. These ratios along with the low levels of DDE and lack of any PCB or DDD residues in fish at the Bear River Migratory Bird Refuge, suggest that most PCBs and possibly DDE in western grebes at Bear River Migratory Bird Refuge were picked up on the wintering grounds along the Pacific Coast. Further supporting this hypothesis is that of all western grebes collected at Bear River Migratory Bird Refuge, the only one that contained no PCBs was a juvenile which had not yet visited the wintering grounds. This bird also had low levels of DDE and DDD.

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REFERENCES

ANDERSON, D. W., J. J. HICKEY, R. W. RISEBROUGH, D. F. HUGHES, and R. E. CHRISTENSEN: Canadian Field Naturalist 83, 91 (1969).

DONALDSON, W. E., T. J. SHEETS, and M. D. JACKSON: Poultry Sci. 47, 237 (1968).

DUSTMAN, E. H., L. F. STICKEL, L. J. BLUSS, W. L. REICHEL, and S. N. WIEMEYER: Trans. of the 36th N. A. Wildl. Nat. Resour. Conf. (1971).

ECOBICHON, D. J., and P. W. SASCHENBRECKER: Toxicol. Appl. Pharmacol. 15, 420 (1969).

FINDLAY, G. M., and S. W. DEFRETAS: Nature 229, 63 (1979).

GREICHUS, Y. A., A. GREICHUS, and R. J. EMERICK: Bull. Environ. Contam. and Toxicol. 9, 321 (1973).

HERMAN, S. G., R. L. GARRETT, and R. L. RUDD: in Miller and Berg, eds. Chemical fallout. Springfield, C. C. Thomas, 1969.

KEITH, J. O.: in J. W. Gillet, ed. The biological impact of pesticides in the environment. Corcallis, Oregon State University, 1969.

KNOPF, F. L., and J. C. STREET: Wilson Bull. 86, 428 (1974).

KURY, C. F.: J. Wildl. Manage. 33, 91 (1969).

PETERSON, J. E., K. M. STAHL, and D. L. MEEKER: Bull. Environ. Contam. and Toxicol. 15, 135 (1976).

PRESST, I., and D. J. JEFFERIES: Bird Study 16, 168 (1969).

RISEBROUGH, R. W., P. REICHE, E. PEAKALL, S. HERMAN, and M. KIRVIN: Nature 220, 1098 (1968).

RUDD, R. L.: Pesticides and the living landscape. Madison, University of Wisconsin Press (1964).

RUDD, R. L., and S. G. HERMAN: In Matsumura, G. Bonsh, and T. Misato eds. Environmental toxicology of pesticides. New York, Academic Press (1972).