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Nationwide Residues of Organochlorine Pesticides in Wings of Mallards and Black Ducks

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ABSTRACT

Nationwide monitoring of organochlorine pesticides in wings of more than 24,000 mallards and black ducks bagged during the 1965 and 1966 hunting seasons showed DDE to be the predominant residue, followed in order by DDT, DDD, dieldrin, and heptachlor epoxide. Residues were generally highest in wings from the Atlantic and Pacific Flyways, and lowest in the Central Flyway. DDE was reported for every State and was notably high in wings from New Jersey, Massachusetts, Connecticut, Rhode Island, New York, Pennsylvania, Alabama, California, and Utah. Dieldrin residues were prevalent in wings from Arkansas, Texas, Utah, California, and several States in the Atlantic Flyway.

Introduction

Nationwide monitoring of organochlorine pesticides in wings of wild mallards and black ducks was initiated by the Bureau of Sport Fisheries and Wildlife in late 1965 as a segment of the National Pesticide Monitoring Program. Findings reported here are based on chemical analyses of wings from more than 24,000 ducks bagged during the 1965 and 1966 hunting seasons. The data provide base readings from which future trends in residue levels can be measured, and they permit geographic comparisons of residues. Wing monitoring is scheduled hereafter at 2- to 3-year intervals. A full description of the Bureau's monitoring commitments has been given by Johnson, Carver, and Dustman (*5*).

The decision to monitor mallard and black duck wings was based on several factors: (a) The combined range of the two species covers the continental United States, the mallard being relatively abundant in all but the Eastern States where the black duck predominates; (b) Wings were readily available as a byproduct of an established nationwide survey of waterfowl productivity wherein each fall cooperating hunters mail the Bureau tens of thousands of duck wings for biological examination; and (c) Dindal and Peterle (*3*), using DDT, ring-labeled with chlorine-36, to study DDT dispersion in a marsh ecosystem, found highly significant correlations in 104 captive mallards and scaup ducks between DDT residues in wings and those in breast skin, kidney, breast muscle, uropygial gland, adrenal gland, pancreas, brain, gonads, liver, and thyroid. The average level in the wings was essentially equal to the median level in the above body parts; it was approximately twice that in breast muscle and about one-eighth that in the uropygial gland.

The monitoring methodology was successfully tested in early 1965 with wings from mallards and black ducks taken in New York and Pennsylvania during the fall of 1964, as reported by Heath and Prouty (*4*). Findings based on analyses of 36 "pools" of wings, each pool composed of 25 defeathered wings chopped and blended into an homogenate, indicated that organochlorine residues were present in all pools and that levels of DDE tended to be higher in wings of adults than in those of immature birds. Wings were analyzed in pools rather than individually to increase the precision of estimates of *average* residue levels from a fixed number of analyses. Variability of residue levels among replicated pools indicated that pool size should not be reduced from 25 wings.

Methods

Wings from the 1965 and 1966 hunting seasons were mailed by selected hunters throughout the United States to one of four regional collecting points and held in frozen storage for examination in early 1966 and 1967. During examination mallard wings from most States and

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black duck wings from Eastern States were first segregated into State groups of immature and adult wings, and each group was then systematically sorted into pools of 25 wings each. A random sample of these pools, roughly proportional in number to a State's mallard or black duck harvest, was selected for pesticidal analysis. Pools not selected were discarded. Each selected pool was enclosed with an individually numbered tag in a plastic bag, packaged in dry ice, and shipped to the analytical laboratory. Records associating pool number with pool description (State and age) were retained by the investigators; thus, pools were identified only by number during chemical analysis.

Wings were analyzed in 1966 by the Hazleton Laboratories, Falls Church, Va., and in 1967 by the Wisconsin Alumni Research Foundation, Madison, Wis. Laboratory selection was by bid. Prior to selection both laboratories satisfactorily analyzed material treated with known amounts of the pesticides expected in monitoring; recovery rates generally exceeded 84%.

Preparatory to analysis, wings were trimmed of flight feathers with a band saw and chopped and blended into 25-wing homogenates with a Hobart food cutter. Residues were measured to a limit of sensitivity of 0.05 ppm (wet weight). Analytical procedures (*1*) were as follows:

Hazleton Laboratories. A 20-g aliquot of the homogenate was dried by grinding with anhydrous sodium sulfate; extracted by shaking and centrifuging three times with petroleum ether (one 100-ml portion and two 50-ml portions); cleaned by acetonitrile-petroleum ether partitioning and elution through a Florisil column in two fractions, the first containing 6% ethyl ether and 94% petroleum ether, and the second containing 15% ethyl ether and 85% petroleum ether. The two fractions were analyzed separately by electron capture gas chromatography using a Chromalab Model A-110 gas chromatograph with a radium-226 detector (Glowall Corporation). The operating parameters were:

Column:	Glass, 6′ x ¼″ OD, packed with 10% DC-200 on 100/120 mesh Gaschrom Q	
Carrier Gas:	N_2 at 120 ml/min	
Temperatures:	Inlet	225 C
	Column	205 C
	Detector	250 C

WARF Institute. A 40-g aliquot of the homogenate was air-dried 96-120 hours at 40 C; extracted in Soxhlet for 8 hours with 70 ml ethyl ether and 170 ml petroleum ether; cleaned and separated by elution through a Florisil column in two fractions, the first containing 5% ethyl ether and 95% petroleum ether, and the second containing 15% ethyl ether and 85% petroleum ether. The two fractions were analyzed separately by electron capture gas chromatography using a Barber-Colman Pesticide Analyzer Model 5360 with a strontium-90 detector. The operating parameters were:

Column:	Glass, 4′ x 4 mm OD, packed with 5% DC-200 on 70/90 mesh Chromport XXX	
Carrier Gas:	N_2 at 70-90 ml/min	
Temperatures:	Inlet	230 C
	Column	200 C
	Detector	240 C

Table 1 lists, by State of collection, the average residue levels of DDE, DDT, DDD, and dieldrin in the wings of adult and immature birds in late 1965 and 1966. The 2-year range in levels and the number of pools in each set are also presented. Table 2 lists the 2-year average levels and standard errors of these chemicals, derived by combining both years' data. The 2-year averages are intended as reference points for detection of trends in future levels. Other chemicals were detected in no more than trace amounts and are discussed in text only.

States are listed in both tables in north-to-south order within each of the four continental waterfowl flyways: Atlantic, Mississippi, Central, and Pacific. Geographic rather than alphabetical listing was used to facilitate geographic comparisons. States were stratified (*2*) by flyways since a majority of mallards and black ducks remain within a given flyway during migration. Essentially, then, we are monitoring flyway as well as State populations, the wings from each State being a sample of that part of a flyway population frequenting the State during its hunting season. Table 3 gives the 2-year flyway means and standard errors for the subject pesticides, derived by weighting (*2*) each State statistic by the estimated total bag in that State of the respective species and age group.

Results

DDE proved to be the predominant residue throughout the survey. Measurable amounts of this stable metabolite of DDT were reported in nearly all pools of adult wings and in most pools of immature wings. Residues of DDE were generally from two to five times higher than those of DDT which, in turn, tended to be higher than those of DDD. Dieldrin was found in wings from more than 30 States, although aldrin, which converts to dieldrin, was not detected. Heptachlor epoxide was reported at trace levels from one-third of the States; heptachlor was not detected. Lindane was found in wings from only two States, and endrin was not detected.

Pronounced State and regional differences in average levels of DDE were apparent. Some of the highest levels were encountered in adult black ducks from a contigu-

ous group of Atlantic Flyway States that included New Hampshire, Massachusetts, Rhode Island, Connecticut, New York, Pennsylvania, New Jersey, and Delaware. DDE averages ranged from 0.88 ppm in New Hampshire to 2.10 ppm in New Jersey. Mallards from the three States sampled in this group—New York, Pennsylvania, and New Jersey—exhibited similarly high residues. Elsewhere, only Alabama, California, and Utah showed comparable levels of DDE. Adult mallards from Alabama had the highest average level in the survey (2.17 ppm), adult black ducks from New Jersey the second highest level (2.10 ppm), and adult mallards from California the second highest level among mallards (1.45 ppm).

In contrast, DDE averaged below 0.14 ppm in both adult and immature mallards from Illinois and Missouri in the Mississippi Flyway and from North Dakota, South Dakota, eastern Montana, Nebraska, Kansas, and Oklahoma in the Central Flyway.

DDT and DDD residues in a given set of pools tended to parallel those of DDE, but at lower levels. Nationwide, DDT exceeded 0.50 ppm in only five sets of pools (immature black ducks from New Jersey were high at 1.72 ppm DDT), and DDD averages failed to exceed 0.50 ppm.

Comparison of average DDE residues in flyway populations (Table 3) shows that levels in black ducks, in the Atlantic Flyway, were the highest in the survey. Among mallards, averages were similarly high in the Atlantic and Pacific Flyways, and about one-third as high in the Mississippi and one-fourth as high in the Central as in either coastal flyway. Average levels of DDT and DDD were highest in the Atlantic Flyway and were usually too low to be quantified in the Mississippi and Central Flyways.

Dieldrin was detected most frequently in the Atlantic Flyway in both mallards and black ducks: wings from only Maine and the combined States of Georgia and Florida failed to show residues. Dieldrin also was prevalent in wings from Arkansas, Texas, Utah, and California; otherwise it was either undetected or present in little more than trace amounts. State averages rarely exceeded 0.25 ppm.

Residue levels of DDE tended to be higher in wings of adults than in those of immature birds, a difference not apparent with DDT, DDD, or dieldrin. This phenomenon, first observed in trial monitoring (*4*), suggests that equilibrium between chemical storage and elimination, in at least the wing, is less readily attained with DDE than with the other chemicals.

Heptachlor epoxide was reported in at least one pool from each of 16 States, nine of them in the Atlantic Flyway. Residues were most prevalent in both mallard and black duck wings from New York and Connecticut where levels averaged about 0.06 ppm. Traces of heptachlor epoxide were also recorded for New Hampshire, Massachusetts, Rhode Island, Pennsylvania, Maryland, Virginia, and North Carolina in the Atlanta Flyway; Ohio, Wisconsin, and Iowa in the Mississippi Flyway; Nebraska in the Central Flyway; and Washington, Oregon, and western Montana in the Pacific Flyway.

Lindane at trace levels was recorded in wings from Washington and Michigan; otherwise, it was not reported. Lindane is recommended by the U. S. Department of Agriculture primarily to control aphids in apple and pear orchards (*7*), which could explain the residues associated with these two orchard States.

Analysis of the ground wing material showed that the homogenates contained approximately 11% lipid material and 36% moisture. (Precise percentages of moisture and lipid content for specific sets of pools are available upon request.)

Discussion

While agricultural uses of pesticides probably accounted for much of the residue material detected in wing monitoring, other sources of contamination should be considered. Sewage from population centers may contribute significant amounts of pesticides to some aquatic environments. Similarly, industrial effluents from pesticide manufacturing plants have been known to contain substantial residues of pesticides lost in chemical processing. It is well known that in some States, vast quantities of DDT have been applied to coastal marshes over the past 2 decades in mosquito control programs. The practice has been especially notable in those States extending from Massachusetts to Delaware.

Because of persistence and a tendency to accumulate in many organisms, substantial residues of DDT, and especially the metabolite DDE, are now present in marsh soils and fauna. Woodwell, Wurster, and Isaacson (*6*) report that residues of DDT and its metabolites averaged more than 13 lb/acre in the soil of an extensive salt marsh on the south shore of Long Island, and that within the marsh, residues increased with trophic levels from 0.04 ppm in plankton to 75 ppm in a ring-billed gull. DDE residues were exceptionally high in wings of both mallards and black ducks from New Jersey, where for many years coastal marshes have been treated with repeated aerial applications of DDT. A number of States are now using chemicals less persistent than DDT in mosquito control work.

Summary and Conclusions

The findings from 2 years of monitoring indicate that duck wings can function as sensitive detectors of environ-

mental DDT and the metabolites DDE and DDD, as well as dieldrin and undoubtedly other organochlorine compounds. Despite some variation due to sampling and analytical processes, residue statistics were sufficiently precise to show differences in levels between flyways, various groups of States, and frequently between individual States. In some instances adjacent States, undoubtedly frequented by many of the same ducks, showed clear differences in residue levels, suggesting rapid assimilation of pesticides into the wing, probably through the diet. The precision with which monitoring will detect trends in wing residue levels will vary from State to State depending upon numbers of wings sampled and the variability in residue concentration within a State's waterfowl habitat.

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See Appendix for chemical names of compounds mentioned in this paper.

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TABLE 1.—*Nationwide residue levels of DDE, DDT, DDD, and dieldrin in pools of 25 wings of mallards or black ducks: fall, 1965 and 1966*

State	Age	Number of Pools		Residues in ppm (wet weight)											
				DDE			DDT			DDD			Dieldrin		
				Pool Means		2-Year Range	Pool Means		2-Year Range	Pool Means		2-Year Range	Pool Means		2-Year Range
		1965	1966	1965	1966		1965	1966		1965	1966		1965	1966	
							BLACK DUCKS, ATLANTIC FLYWAY								
Maine	Ad.	4	4	0.46	0.49	0.32-0.82	0.08	0.06	n -0.17	0.06	0.06	n -0.16	n	n	—
	Imm.	4	4	0.16	0.42	0.11-0.88	0.05	0.17	n -0.41	T	T	n -0.11	n	n	—
Vt.	Ad.	3	3	1.07	0.42	0.18-2.10	0.12	0.08	n -0.21	0.11	0.05	n -0.15	n	n	—
	Imm.	3	3	0.20	0.16	0.12-0.20	0.05	T	n -0.10	0.05	n	n -0.10	0.45	n	n -1.30
N. H.	Ad.	3	3	1.06	0.70	0.48-2.17	0.27	0.06	n -0.46	0.12	n	n -0.20	0.20	n	n -0.55
	Imm.	3	3	0.21	0.28	0.14-0.43	0.17	0.08	n -0.32	n	n	—	0.06	n	n -0.10
Mass.	Ad.	4	4	1.73	1.65	1.28-2.67	0.38	0.18	n -0.52	0.21	0.12	n -0.28	0.17	T	n -0.38
	Imm.	4	4	0.63	1.42	0.29-2.40	0.37	0.37	n -0.89	0.21	0.14	n -0.34	0.18	0.06	n -0.24
Conn.	Ad.	3	3	1.62	1.39	0.77-2.62	0.78	0.26	n -0.90	0.67	0.17	n -0.72	0.11	n	n -0.18
	Imm.	3	3	0.73	0.43	0.30-1.00	0.32	0.12	n -0.42	0.22	0.09	n -0.29	1.04	n	n -2.97
R. I.	Ad.	3	3	0.77	1.11	0.56-1.50	0.23	0.11	n -0.34	0.19	0.05	n -0.27	0.31	0.10	n -0.43
	Imm.	3	3	0.29	0.96	0.27-1.00	0.26	0.14	n -0.36	0.08	0.08	n -0.13	0.14	0.11	n -0.23
N. Y.	Ad.	4	4	1.36	1.12	0.78-1.58	0.45	T	n -0.50	0.19	0.07	n -0.24	0.05	T	n -0.15
	Imm.	4	4	0.38	1.18	0.20-1.50	0.25	0.46	n -0.94	0.13	0.11	n -0.28	0.10	0.05	n -0.17
Pa.	Ad.	3	3	1.78	0.50	0.33-3.60	0.16	n	n -0.18	0.11	n	n -0.14	0.05	n	n -0.10
	Imm.	3	3	0.55	0.15	0.10-0.82	0.18	0.05	n -0.24	0.10	n	n -0.20	0.06	n	n -0.13
N. J.	Ad.	5	5	1.94	2.26	1.32-3.45	0.78	0.77	0.45-1.31	0.18	0.13	n -0.25	0.05	n	n -0.08
	Imm.	5	5	1.58	1.86	0.94-4.10	1.63	1.80	0.40-4.90	0.26	0.17	0.08-0.42	T	T	n -0.11
Del.	Ad.	3	3	0.59	1.17	0.50-1.50	0.14	0.07	n -0.19	0.08	T	n -0.13	n	0.08	n -0.19
	Imm.	3	3	0.10	0.47	n -0.72	0.06	0.13	n -0.35	0.06	T	n -0.11	n	n	—

TABLE 1.—*Nationwide residue levels of DDE, DDT, DDD, and dieldrin in pools of 25 wings of mallards or black ducks: fall, 1965 and 1966*—Continued

State	Age	Number of Pools		Residues in ppm (wet weight)											
				DDE			DDT			DDD			Dieldrin		
				Pool Means		2-Year Range	Pool Means		2-Year Range	Pool Means		2-Year Range	Pool Means		2-Year Range
		1965	1966	1965	1966		1965	1966		1965	1966		1965	1966	
BLACK DUCKS, ATLANTIC FLYWAY—Continued															
Md.	Ad.	3	3	0.22	0.43	0.13-0.51	0.13	0.06	n -0.14	0.11	T	n -0.13	T	n	n -0.06
	Imm.	3	3	0.15	0.56	0.12-1.30	n	0.16	n -0.37	n	n	—	0.05	n	n -0.07
Va.	Ad.	3	3	0.25	0.54	0.20-0.72	T	n	n -0.06	0.05	0.05	n -0.12	0.20	n	n -0.43
	Imm.	3	3	0.28	0.19	0.09-0.42	0.07	n	n -0.18	T	n	n -0.09	0.39	n	n -0.78
N. C.	Ad.	1	2	0.48	0.48	0.31-0.66	0.12	0.07	n -0.12	0.11	n	n -0.11	n	n	—
	Imm.	2	1	0.41	0.18	0.18-0.45	0.12	n	n -0.18	0.13	n	n -0.16	0.08	n	n -0.11
S. C.	Ad.	2	2	0.21	0.38	0.18-0.53	0.10	n	n -0.10	n	n	—	n	0.05	n -0.07
	Imm.	2	2	0.64	0.38	0.38-0.69	0.21	0.20	0.19-0.21	0.05	n	n -0.09	0.16	n	n -0.16
MALLARDS, ATLANTIC FLYWAY															
N. Y.	Ad.	3	3	1.70	0.78	0.52-2.15	1.24	n	n -2.98	0.26	n	n -0.30	0.06	n	n -0.11
	Imm.	3	3	0.45	0.35	0.21-0.61	0.32	0.19	n -0.42	0.23	n	n -0.30	0.05	n	n -0.08
Pa.	Ad.	3	3	0.39	1.16	0.37-1.50	0.20	0.14	n -0.25	0.09	0.05	n -0.14	n	0.09	n -0.16
	Imm.	3	3	1.71	0.65	0.14-4.49	0.64	0.05	n -1.59	0.14	0.07	n -0.18	n	0.08	n -0.12
N. J.	Ad.	3	3	1.00	1.85	0.40-2.60	0.46	0.55	0.05-1.20	0.08	0.17	n -0.22	T	n	n -0.06
	Imm.	3	3	0.59	0.54	0.33-0.70	0.33	0.37	n -0.75	0.12	0.10	0.08-0.17	n	n	—
Md.	Ad.	3	2	0.26	0.70	0.20-0.84	0.05	n	n -0.12	0.05	n	n -0.10	n	0.10	n -0.17
	Imm.	3	3	0.42	0.17	0.14-0.46	0.19	n	n -0.21	0.20	n	n -0.32	0.07	T	n -0.18
Va.	Ad.	3	3	0.24	0.36	0.19-0.59	0.06	T	n -0.10	0.06	n	n -0.08	0.08	T	n -0.11
	Imm.	3	3	0.16	0.20	0.07-0.28	0.08	n	n -0.14	0.11	n	n -0.19	n	n	—
S. C.	Ad.	3	3	0.17	0.56	0.13-1.00	T	0.09	n -0.23	n	n	—	T	0.07	n -0.16
	Imm.	3	3	0.10	0.36	0.05-0.76	0.05	0.19	n -0.47	n	n	—	0.05	n	n -0.08
Ga. and Fla.	Ad.	2	2	0.53	0.52	0.35-0.70	0.13	0.05	n -0.15	0.08	n	n -0.10	n	n	—
	Imm.	2	3	1.18	0.13	0.11-1.81	0.24	n	n -0.29	n	n	—	n	n	—
MALLARDS, MISSISSIPPI FLYWAY															
Minn.	Ad.	7	6	0.25	0.22	0.08-0.52	n	T	n -0.10	n	n	—	n	n	—
	Imm.	6	6	0.10	0.07	n -0.22	T	n	n -0.10	n	n	—	n	n	—
Wis.	Ad.	3	5	0.50	0.14	0.08-0.81	0.28	n	n -0.68	0.21	n	n -0.60	n	T	n -0.05
	Imm.	4	5	0.14	T	n -0.19	T	n	n -0.09	n	n	—	0.08	n	n -0.20
Mich.	Ad.	2	3	0.29	0.18	0.10-0.48	0.11	T	n -0.20	0.07	n	n -0.11	n	n	—
	Imm.	4	3	0.13	0.11	0.09-0.19	n	0.07	n -0.16	n	n	—	n	n	—
Iowa	Ad.	5	5	0.32	0.12	0.06-0.92	0.06	n	n -0.24	T	n	n -0.14	n	n	—
	Imm.	5	5	0.14	T	n -0.39	n	n	—	n	n	—	n	n	—
Ill.	Ad.	7	6	0.10	0.08	n -0.27	n	n	—	n	n	—	n	T	n -0.06
	Imm.	6	6	0.05	0.18	n -0.49	n	n	—	n	n	—	T	n	n -0.07
Ind.	Ad.	4	3	0.23	0.09	0.06-0.29	0.05	n	n -0.12	T	T	n -0.08	n	n	—
	Imm.	4	3	0.15	0.09	n -0.20	0.08	n	n -0.15	T	0.08	n -0.19	n	n	—
Ohio	Ad.	3	3	0.18	0.30	0.15-0.31	n	0.11	n -0.17	0.05	0.16	n -0.31	n	n	—
	Imm.	4	3	0.11	0.45	0.09-1.01	0.06	0.14	n -0.25	0.07	n	n -.013	T	n	n -0.08
Mo.	Ad.	6	5	0.23	n	n -0.72	T	n	n -0.12	n	n	—	n	n	—
	Imm.	5	5	T	T	n -0.12	n	n	—	n	n	—	n	n	—
Ky.	Ad.	3	3	0.30	0.30	0.13-0.62	0.08	0.09	n -0.23	T	0.06	n -0.10	n	n	—
	Imm.	3	3	0.13	0.09	0.06-0.16	0.05	n	n -0.10	0.05	n	n -0.10	n	n	—
Ark.	Ad.	7	6	0.19	0.21	0.08-0.31	0.06	0.07	n -0.15	T	n	n -0.05	0.11	0.06	n -0.34
	Imm.	6	6	0.15	0.09	0.05-0.29	0.06	0.06	n -0.15	n	T	n -0.06	0.08	0.12	n -0.31
Tenn.	Ad.	5	4	0.38	0.27	0.11-1.10	0.06	0.05	n -0.12	T	n	n -0.09	n	0.11	n -0.39
	Imm.	4	4	0.13	0.16	0.05-0.30	T	0.06	n -0.12	T	n	n -0.09	0.06	n	n -0.16
La.	Ad.	5	6	0.22	0.11	0.05-0.26	0.06	0.06	n -0.11	n	n	—	T	n	n -0.05
	Imm.	5	6	0.07	0.15	n -0.34	T	0.09	n -0.22	n	T	n -0.06	T	0.12	n -0.19

TABLE 1.—*Nationwide residue levels of DDE, DDT, DDD, and dieldrin in pools of 25 wings of mallards or black ducks: fall, 1965 and 1966*—Continued

State	Age	Number of Pools		Residues in ppm (wet weight)											
				DDE			DDT			DDD			Dieldrin		
				Pool Means		2-Year Range	Pool Means		2-Year Range	Pool Means		2-Year Range	Pool Means		2-Year Range
		1965	1966	1965	1966		1965	1966		1965	1966		1965	1966	
MALLARDS, MISSISSIPPI FLYWAY—Continued															
Miss.	Ad.	3	3	0.73	0.28	0.21-0.96	0.20	0.12	0.08-0.27	0.06	n	n -0.08	n	T	n -0.05
	Imm.	3	3	0.22	0.23	0.07-0.50	0.11	0.12	n -0.16	n	n	—	n	T	n -0.06
Ala.	Ad.	2	3	0.88	3.03	0.54-5.31	0.23	0.26	0.13-0.45	0.10	0.27	n -0.49	0.14	n	n -0.14
	Imm.	3	3	0.68	2.21	0.42-3.23	0.35	0.44	0.15-0.69	0.14	0.84	0.06-2.03	n	n	—
MALLARDS, CENTRAL FLYWAY															
Mont.	Ad.	8	4	0.08	0.12	0.05-0.16	n	n	—	n	n	—	T	T	n -0.16
(eastern)	Imm.	8	4	0.10	0.07	n -0.29	T	0.06	n -0.15	n	0.06	n -0.19	T	n	n -0.16
N. Dak.	Ad.	8	8	0.12	0.11	0.05-0.43	n	n	—	n	n	—	n	n	—
	Imm.	8	8	T	n	n -0.05	n	n	—	n	n	—	n	n	—
S. Dak.	Ad.	7	8	0.09	0.12	n -0.20	n	T	n -0.10	n	n	—	n	n	—
	Imm.	6	8	T	0.08	n -0.34	n	n	—	n	n	—	n	n	—
Wyo.	Ad.	1	3	0.05	0.20	0.05-0.45	n	0.12	n -0.32	n	T	n -0.05	n	n	—
(eastern)	Imm.	2	3	n	0.09	n -0.10	n	n	—	n	n	—	n	n	—
Nebr.	Ad.	6	7	0.10	0.09	0.05-0.17	n	n	—	n	n	—	n	n	—
	Imm.	6	7	T	T	n -0.10	n	T	n -0.09	n	n	—	n	n	—
Colo.	Ad.	10	4	0.33	0.24	0.17-0.85	0.24	0.25	n -1.20	0.05	0.07	n -0.18	n	n	—
(eastern)	Imm.	10	4	0.31	0.17	0.05-0.69	0.20	0.55	n -0.81	T	T	n -0.11	n	n	—
Kans.	Ad.	7	6	0.08	0.08	n -0.12	n	n	—	n	n	—	n	n	—
	Imm.	7	6	0.15	T	n -0.91	n	T	n -0.09	n	n	—	n	n	—
N. Mex.	Ad.	3	3	0.31	1.17	0.22-2.44	n	0.11	n -0.19	n	n	—	n	T	n -0.06
(eastern)	Imm.	3	3	0.39	0.63	0.20-1.35	n	0.12	n -0.22	n	n	—	n	n	—
Okla.	Ad.	5	4	0.12	0.10	0.07-0.20	n	n	—	n	n	—	n	n	—
	Imm.	3	4	n	0.07	n -0.12	n	n	—	n	n	—	n	n	—
Tex.	Ad.	6	9	0.19	0.45	0.12-1.14	0.10	0.07	n -0.36	n	T	n -0.17	0.06	0.10	n -0.53
	Imm.	4	9	0.10	0.34	n -0.74	0.08	0.14	n -0.74	n	T	n -0.10	n	0.09	n -0.28
MALLARDS, PACIFIC FLYWAY															
Wash.	Ad.	13	11	0.27	0.70	0.06-2.75	0.05	0.09	n -0.38	T	T	n -0.14	n	T	n -0.10
	Imm.	13	11	0.42	0.31	0.10-1.36	0.18	0.06	n -0.72	T	n	n -0.08	T	T	n -0.07
Oreg.	Ad.	7	7	0.36	0.35	0.12-0.59	0.06	T	n -0.17	T	n	n -0.12	n	T	n -0.09
	Imm.	7	7	0.27	0.32	0.08-1.56	0.05	0.13	n -0.42	n	n	—	n	n	—
Idaho	Ad.	9	9	0.64	0.37	0.06-2.77	0.28	0.05	n -1.00	0.08	T	n -0.36	n	T	n -0.09
	Imm.	9	9	0.21	0.52	n -1.50	0.06	0.06	n -0.20	n	n	—	n	n	—
Mont.	Ad.	4	4	0.13	0.20	0.08-0.34	n	T	n -0.07	n	n	—	n	T	n -0.06
(western)	Imm.	4	4	0.16	0.04	n -0.30	0.09	n	n -0.30	T	n	n -0.10	n	n	—
Wyo.	Ad.	2	3	T	0.09	n -0.10	n	n	—	n	n	—	n	n	—
(western)	Imm.	3	3	0.05	0.07	n -0.11	n	n	—	n	n	—	n	n	—
Calif.	Ad.	11	11	1.41	1.49	0.20-3.50	0.32	0.20	n -1.67	0.06	n	n -0.21	T	T	n -0.08
	Imm.	11	11	0.96	1.30	0.29-4.11	0.08	0.22	n -0.38	0.17	n	n -0.60	0.06	0.18	n -0.94
Nev.	Ad.	2	3	0.32	0.17	0.08-0.37	n	T	n -0.09	n	T	n -0.08	n	n	—
	Imm.	3	3	0.11	0.67	0.06-1.56	T	T	n -0.08	n	n	—	n	n	—
Utah	Ad.	6	5	0.66	1.26	0.39-1.41	0.20	0.13	n -0.54	T	T	n -0.12	T	0.06	n -0.16
	Imm.	6	5	0.86	0.68	0.37-1.30	0.25	0.09	n -0.76	0.07	0.05	n -0.16	0.08	0.09	n -0.28
Colo.	Ad.	3	3	1.15	0.22	0.11-3.20	0.68	n	n -1.94	0.12	n	n -0.33	n	n	—
(western)	Imm.	3	3	0.24	0.10	0.10-0.34	n	n	—	n	n	—	T	n	n -0.09
Ariz. and N. Mex.	Ad.	1	3	0.12	0.34	n -0.73	0.09	T	n -0.09	n	n	—	0.12	n	n -0.12
(western)	Imm.	2	3	0.42	0.63	0.11-0.98	0.45	0.10	n -0.88	0.43	n	n -0.85	n	n	—

NOTE: Means were computed by assigning the trace value 0.02 ppm to pool residues below the limit of sensitivity (0.05 ppm).
T = Residues reported, but mean level probably a trace (below 0.05 ppm).
n = Residues not detectable at 0.05 ppm limit of sensitivity.

TABLE 2.—*Nationwide residue levels of DDE, DDT, DDD, and dieldrin in wings of mallards or black ducks: 1965-1966*

[Estimates are 2-year means and standard errors for pools of 25 wings each]

State	Age	Total Pools 1965 + 1966	Residues in ppm (wet weight)							
			DDE		DDT		DDD		Dieldrin	
			2-Year Mean	Standard Error	2-Year Mean	Standard Error	2-Year Mean	Standard Error	2-Year Mean	Standard Error
BLACK DUCKS, ATLANTIC FLYWAY										
Maine	Ad.	8	0.48	.064	0.07	.023	0.06	.021	[1](0.02)	[1](.006)
	Imm.	8	0.29	.099	0.11	.048	(0.04)	.015	(0.02)	(.006)
Vt.	Ad.	6	0.75	.279	0.10	.033	0.08	.025	(0.02)	(.008)
	Imm.	6	0.18	.013	(0.04)	(.018)	(0.03)	.017	0.23	.217
N. H.	Ad.	6	0.88	.262	0.17	.072	0.07	.034	0.10	.092
	Imm.	6	0.25	.043	0.13	.050	(0.02)	(.008)	(0.04)	(.017)
Mass.	Ad.	8	1.69	.166	0.28	.065	0.18	.039	0.10	.045
	Imm.	8	1.03	.239	0.23	.109	0.18	.037	0.12	.030
Conn.	Ad.	6	1.51	.311	0.52	.135	0.42	.120	0.06	.029
	Imm.	6	0.58	.175	0.22	.061	0.16	.042	0.53	.491
R. I.	Ad.	6	0.94	.156	0.17	.059	0.12	.042	0.21	.061
	Imm.	6	0.63	.151	0.19	.053	0.08	.018	0.12	.035
N. Y.	Ad.	8	1.24	.092	0.24	0.82	0.13	.036	0.05	.021
	Imm.	8	0.78	.165	0.36	.103	0.12	.038	0.08	.022
Pa.	Ad.	6	1.14	.511	0.09	.033	0.06	.025	(0.03)	(.016)
	Imm.	6	0.35	.134	0.11	.039	0.06	.033	(0.04)	(.021)
N. J.	Ad.	10	2.10	.228	0.78	.103	0.15	.103	(0.03)	(.010)
	Imm.	10	1.75	.303	1.72	.402	0.21	.402	(0.03)	(.012)
Del.	Ad.	6	0.88	.171	0.11	.033	0.07	.034	0.05	.032
	Imm.	6	0.29	.102	0.10	.057	0.05	.019	(0.02)	(.008)
Md.	Ad.	6	0.33	.056	0.10	.026	0.07	.029	(0.03)	(.010)
	Imm.	6	0.36	.190	0.09	.059	(0.02)	(.008)	0.05	.013
Va.	Ad.	6	0.40	.077	(0.03)	(.012)	0.05	.025	0.11	.071
	Imm.	6	0.24	.054	0.05	.031	(0.03)	(.015)	0.21	.133
N. C.	Ad.	3	0.48	.101	0.09	.040	0.05	.037	(0.02)	(.017)
	Imm.	3	0.33	.080	0.09	.053	0.09	.046	0.06	.032
S. C.	Ad.	4	0.30	.081	0.10	.031	(0.02)	(.013)	(0.03)	(.017)
	Imm.	4	0.51	.078	0.21	.005	(0.04)	(.022)	0.07	.053
MALLARDS, ATLANTIC FLYWAY										
N. Y.	Ad.	6	1.24	.237	0.63	.478	0.14	.058	T	—
	Imm.	6	0.40	.059	0.24	.062	0.12	.056	T	—
Pa.	Ad.	6	0.78	.189	0.17	.035	0.07	.023	0.05	.027
	Imm.	6	1.18	.682	0.35	.251	0.11	.033	0.05	.022
N. J.	Ad.	6	1.08	.383	0.51	.195	0.13	.034	T	—
	Imm.	6	0.57	.060	0.35	.108	0.11	.013	n	—
Md.	Ad.	5	0.44	.118	0.05	.025	0.05	.020	0.05	.034
	Imm.	6	0.30	.058	0.11	.039	0.11	.053	0.05	.030
Va.	Ad.	6	0.30	.061	0.05	.017	(0.04)	(.016)	0.06	.018
	Imm.	6	0.18	.030	(0.04)	(.026)	0.07	.034	n	—
S. C.	Ad.	6	0.37	.133	0.07	.038	(0.02)	(.008)	0.05	.026
	Imm.	6	0.23	.109	0.12	.072	(0.02)	(.008)	T	—
Ga. and Fla.	Ad.	4	0.53	.079	0.09	.029	0.05	.024	n	—
	Imm.	5	0.66	.325	0.11	.057	(0.02)	(.010)	n	—

TABLE 2.—*Nationwide residue levels of DDE, DDT, DDD, and dieldrin in wings of mallards or black ducks: 1965-1966*—Continued

[Estimates are 2-year means and standard errors for pools of 25 wings each]

State	Age	Total Pools 1965 + 1966	Residues in ppm (wet weight)							
			DDE		DDT		DDD		Dieldrin	
			2-Year Mean	Standard Error	2-Year Mean	Standard Error	2-Year Mean	Standard Error	2-Year Mean	Standard Error
MALLARDS, MISSISSIPPI FLYWAY										
Minn.	Ad.	13	0.24	.039	(0.03)	(.053)	n	—	n	—
	Imm.	12	0.08	.019	T	—	n	—	n	—
Wis.	Ad.	8	0.28	.096	0.12	.084	0.09	.075	T	—
	Imm.	9	0.08	.021	T	—	n	—	0.05	.023
Mich.	Ad.	5	0.22	.067	0.06	.039	T	—	n	—
	Imm.	7	0.12	.013	T	—	n	—	n	—
Iowa	Ad.	10	0.22	.080	0.09	.024	T	—	n	—
	Imm.	10	0.09	.037	n	—	n	—	n	—
Ill.	Ad.	13	0.09	.020	(0.02)	(.004)	n	—	T	—
	Imm.	12	0.12	.037	n	—	n	—	T	—
Ind.	Ad.	7	0.17	.034	0.06	.017	T	—	T	—
	Imm.	7	0.12	.024	T	—	0.05	.027	T	—
Ohio	Ad.	6	0.24	.028	0.06	.028	0.11	.044	n	—
	Imm.	7	0.26	.127	0.11	.032	0.05	.022	T	—
Mo.	Ad.	11	0.13	.065	(0.03)	(.011)	n	—	n	—
	Imm.	10	(0.04)	.012	n	—	n	—	n	—
Ky.	Ad.	6	0.30	.080	0.08	.039	0.05	.018	n	—
	Imm.	6	0.11	.018	T	—	T	—	n	—
Ark.	Ad.	13	0.20	.021	0.06	.015	T	—	0.08	.028
	Imm.	12	0.12	.024	0.06	.017	T	—	0.10	.021
Tenn.	Ad.	9	0.33	.099	0.05	.018	T	—	0.06	.043
	Imm.	8	0.15	.031	0.05	.018	T	—	T	—
La.	Ad.	11	0.18	.018	(0.04)	(.014)	n	—	T	—
	Imm.	11	0.11	.029	0.06	.025	T	—	0.07	.019
Miss.	Ad.	6	0.51	.137	0.16	.026	T	—	T	—
	Imm.	6	0.23	.060	0.11	.027	n	—	T	—
Ala.	Ad.	5	2.17	.922	0.24	.061	0.20	.084	0.05	.035
	Imm.	6	1.45	.525	0.40	.078	0.49	.312	n	—
MALLARDS, CENTRAL FLYWAY										
Mont. (eastern)	Ad.	12	0.09	.010	n	—	n	—	T	—
	Imm.	12	0.09	.026	T	—	T	—	T	—
N. Dak.	Ad.	16	0.12	.022	n	—	n	—	n	—
	Imm.	16	(0.03)	(.003)	n	—	n	—	n	—
S. Dak.	Ad.	15	0.11	.014	T	—	n	—	n	—
	Imm.	14	0.06	.025	n	—	n	—	n	—
Wyo. (eastern)	Ad.	4	0.16	.097	0.10	.080	T	—	n	—
	Imm.	5	0.06	.017	n	—	n	—	n	—
Nebr.	Ad.	13	0.10	.009	n	—	n	—	n	—
	Imm.	13	(0.04)	(.009)	T	—	n	—	n	—
Colo. (eastern)	Ad.	14	0.30	.048	0.24	.093	0.05	.016	n	—
	Imm.	14	0.27	.041	0.22	.067	T	—	n	—
Kans.	Ad.	13	0.08	.009	n	—	n	—	n	—
	Imm.	13	0.09	.070	T	—	n	—	n	—
N. Mex. (eastern)	Ad.	6	0.74	.349	0.06	.033	n	—	T	—
	Imm.	6	0.51	.185	0.07	.035	n	—	n	—
Okla.	Ad.	9	0.11	.016	n	—	n	—	n	—
	Imm.	7	0.05	.017	n	—	n	—	n	—
Tex.	Ad.	15	0.35	.072	0.08	.025	T	—	0.08	.037
	Imm.	13	0.27	.071	0.12	.057	T	—	0.07	.025

TABLE 2.—*Nationwide residue levels of DDE, DDT, DDD, and dieldrin in wings of mallards or black ducks: 1965-1966*—Continued

[Estimates are 2-year means and standard errors for pools of 25 wings each]

State	Age	Total Pools 1965 + 1966	Residues in ppm (wet weight): DDE 2-Year Mean	DDE Standard Error	DDT 2-Year Mean	DDT Standard Error	DDD 2-Year Mean	DDD Standard Error	Dieldrin 2-Year Mean	Dieldrin Standard Error
			MALLARDS, PACIFIC FLYWAY							
Wash.	Ad.	24	0.47	.125	0.07	.017	T	—	T	—
	Imm.	24	0.37	.063	0.12	.037	T	—	T	—
Oreg.	Ad.	14	0.36	.038	0.07	.017	T	—	T	—
	Imm.	14	0.30	.113	0.09	.030	n	—	n	—
Idaho	Ad.	18	0.51	.140	0.17	.060	0.05	.020	T	—
	Imm.	18	0.37	.084	0.05	.014	n	—	n	—
Mont. (western)	Ad.	8	0.17	.031	(0.03)	(.009)	n	—	T	—
	Imm.	8	0.10	.040	0.06	.037	T	—	n	—
Wyo. (western)	Ad.	5	0.07	.015	(0.02)	(.010)	n	—	n	—
	Imm.	6	0.06	.022	(0.02)	(.008)	n	—	n	—
Calif.	Ad.	22	1.45	.174	0.26	.070	T	—	T	—
	Imm.	22	1.13	.210	0.15	.025	0.10	.033	0.12	.046
Nev.	Ad.	5	0.23	.047	(0.03)	(.020)	T	—	n	—
	Imm.	6	0.39	.237	(0.04)	(.015)	n	—	n	—
Utah	Ad.	11	0.93	.102	0.17	.046	T	—	0.05	.019
	Imm.	11	0.78	.079	0.18	.066	0.06	.018	0.08	.030
Colo. (western)	Ad.	6	0.69	.504	0.35	.320	0.07	.003	n	—
	Imm.	6	0.17	.040	(0.02)	(.008)	n	—	T	—
Ariz. and N. Mex.	Ad.	4	0.31	.146	0.05	.022	n	—	0.05	.030
	Imm.	5	0.55	.156	0.24	.167	0.19	.170	n	—

[1] Parenthesized trace values were estimated numerically to compute average flyway levels; corresponding standard errors are maximized estimates.

NOTE: Means were computed by assigning the trace value 0.02 ppm to pool residues below the limit of sensitivity (0.05 ppm).
T = Residues reported but mean level probably a trace (below 0.05 ppm).
n = Residues not detectable at 0.05 ppm limit of sensitivity.

TABLE 3.—*Residues of DDE, DDT, DDD, and dieldrin, by waterfowl flyways, in pools of 25 wings of mallards or black ducks: 1965-1966*

[Estimates are 2-year means and standard errors weighted by each State's total bag of the given species and age group.]

Species	Flyway	Age	Number of Pools	Residues in ppm (wet weight): DDE 2-Year Mean	DDE Standard Error	DDT 2-Year Mean	DDT Standard Error	DDD 2-Year Mean	DDD Standard Error	Dieldrin 2-Year Mean	Dieldrin Standard Error
Black duck	Atlantic	Ad.	89	1.23	.078	0.33	.031	0.12	.029	0.05	.008
		Imm.	89	0.75	.071	0.46	.076	0.11	.073	0.11	.034
Mallard	Atlantic	Ad.	39	0.72	.078	0.25	.095	0.07	.013	T	—
		Imm.	41	0.60	.183	0.24	.071	0.10	.022	T	—
Mallard	Mississippi	Ad.	123	0.25	.024	0.06	.011	T	—	T	—
		Imm.	123	0.12	.011	T	—	T	—	T	—
Mallard	Central	Ad.	117	0.17	.017	T	—	T	—	T	—
		Imm.	113	0.09	.014	T	—	T	—	T	—
Mallard	Pacific	Ad.	117	0.70	.063	0.14	.022	T	—	T	—
		Imm.	120	0.59	.068	0.11	.015	0.05	—	0.05	—

NOTE: Means were computed by assigning the trace value 0.02 ppm to pool residues below the limit of sensitivity (0.05 ppm).
T = Residues reported, but mean level probably a trace (below 0.05 ppm).