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Continuing Organochlorine Insecticide Mortality in Wild Birds in New York, 2000–2004

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More than two decades have elapsed since most uses of chlordane, dieldrin and DDT (dichlorodiphenyltrichlorethane) were banned in the United States. Despite the passage of time, these persistent insecticides, particularly the cyclodienes chlordane and dieldrin, continued to kill birds in New York and New Jersey through the 1990's, primarily through contamination of food chains linked to soil-dwelling invertebrates in historically treated soils (Okoniewski and Novesky 1993, Stansley and Roscoe 1999, Stone, unpublished). Herein we present findings from 2000-2004 which suggest that avian morbidity and mortality from organochlorine (OC) pesticides continues at a significant level in New York in the new century.

MATERIALS AND METHODS

The birds in this report were found dead or moribund by the general public. The majority were reported to and submitted through county health departments as part of New York's West Nile Virus (WNV) monitoring program (Eidson et al. 2001). The remainder were submitted directly to the New York wildlife pathology laboratory by the finders, or through animal control officers and wildlife rehabilitators. All birds were grossly examined externally and internally to make a tentative diagnosis. Samples of brain, heart, and kidney were collected for WNV testing by the New York State Department of Health. When OC insecticide poisoning was considered a possible mortality factor based on clinical signs (tremors, seizures) or gross findings (lack of fat, slight loss of muscle mass, minimal volume of alimentary canal contents), brain tissue was collected and frozen in a glass jar prior to shipment to either the Mississippi State Chemical Laboratory (Mississippi State, MS) or Enchem, Inc. (Madison, WI). During 2000 and 2001, analyses were sometimes ordered prior to completion of the WNV test. In subsequent years, analyses were conducted only on tissues from birds which had tested negative for WNV. Although suspected poisonings of raptors were consistently followed-up with analytical findings in all five years, testing of non-raptors was extensive only in 2001 due to fiscal limitations.

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At Mississippi State, OC insecticides were determined by gas chromatography using capillary columns with electron capture detectors according to modifications of methods described in USEPA (1980). Sample clean-up was performed on a fluorosil column, and polychlorinated biphenyls were separated from pesticides using a silicic acid column on the first fluorosil fraction. Chemical reference standards (96-100% purity) were principally obtained from the U.S. Environmental Protection Agency National Pesticide Standard Repository (Fort Meade, MD). Standards for endrin and endosulfan were obtained from Accustandard, Inc.(New Haven, CT), and Velsicol Chemical Corporation (Rosemont, IL), respectively. Comparable analyses at Enchem were completed according to EPA methods 8081A and 8082 (USEPA 1996) using reference standards (97-100% purity) from Absolute Standards, Inc. (Hamden, CT), Supelco (Bellefonte, PA), and Restek Corporation (Bellefonte, PA). Mean spike recoveries for diagnostically relevant compounds at Mississippi State during the period in question were 90% for oxychlordane, 92% for HE (heptachlor epoxide), 86% for dieldrin, 89% for DDE (dichlorodiphenyldichloroethylene), 90% for DDD (dichlodiphenyldichloroethane), and 93% for DDT. Mean spike recoveries at Enchem were 91% (HE), 98% (dieldrin), 127% (DDE), 99% (DDD), 110% (DDT). Analytical results are not adjusted for recovery, and levels are expressed as ug/g wet weight. In one case, the results were adjusted (multiplied by 0.75 to counterbalance an estimated 25% loss of water) due to dehydration of a small sample during storage.

In brain tissue, DDT-related poisoning was considered a probable cause of death when the total DDT equivalents were $\geq$20 μg/g, where 15 μg/g DDE or 5 μg/g DDD is equivalent to 1 μg/g DDT (Stickel et al. 1970). Dieldrin intoxication was supported by levels $\geq$4 μg/g (Stickel et al.1969). Poisoning with chlordane-related compounds (CRCs) were considered likely when the sum of oxychlordane (OXY) and heptachlor epoxide (HE) exceeded 4 μg/g. This criteria was derived from the experimental study of Stickel et al. (1979) and our own observations of birds dead in the field (Okoniewski and Novesky 1993, Stone unpublished). Lethal combinations of dieldrin and CRCs (cyclodiene compounds with same mode of action) was similarly considered probable when the combined sum of OXY, HE, and dieldrin was $\geq$4.0 μg/g.

RESULTS AND DISCUSSION

Potentially lethal levels of OC insecticides were detected in the brains of 165 birds representing 15 species (Table 1). The large number of crows and jays was in part because of the corvid focus of the WNV surveillance program.

Potentially lethal levels of CRCs were present in 137 of these 165 birds (83% of the total). The geometric mean (g.m.) sum of OXY + HE for these birds was 7.6 μg/g (range = 4.0-17.6 μg/g). A potentially lethal level of dieldrin was found in 27 birds (16%); g.m. = 8.7 μg/g, range = 4.0-27.0 μg/g). In 10 birds, the levels of CRCs and dieldrin were both above the diagnostic threshold for lethal

Table 1. Poisonings of wild birds with organochlorine insecticides documented in New York, 2000-2004.

Species	no. birds	Principal Toxicant(s)				
		CRCs[a]	Dieldrin	CRCs+Dield 1[b]	CRCs+Dield 2[c]	DDTR[d]
Sharp-shinned Hawk (*Accipiter striatus*)	2	1		1		
Cooper's Hawk (*A. cooperii*)	30	22	3	3	2	
Red-tailed Hawk (*Buteo jamaicensis*)	11	8	2	1		
American Kestrel (*Falco sparverius*)	4	3		1		
Merlin (*F. columbarius*)	2	2				
Screech owl (*Otus asio*)	1	1				
Great Horned Owl (*Bubo virginianus*)	5	4			1	
Northern Flicker (*Colaptes auratus*)	2		2			
Blue Jay (*Cyanocitta cristata*)	46	38	6	1	1	
American Crow (*Corvus brachyrhynchos*)	39	31	3	1	4	
Fish Crow (*Corvus ossifragus*)	3	2			1	
Northern Mockingbird (*Mimus polyglottis*)	1	1				
American Robin (*Turdus migratorius*)	11	7		1		3
European Starling (*Sturnus vulgarius*)	5	4		1		
Common Grackle (*Quiscalus quiscula*)	2	1		1		
House Sparrow (*Passer domesticus*)	1	1				

[a]Chlordane-related compounds; cases in which the sum of oxychlordane and heptachlor epoxide were ≥4.0 μg/g (wet basis) in brain.

[b]Cases in which the brain levels of CRCs and dieldrin were both above the minimum potential lethal level of ≥4.0 μg/g.

[c]Cases in which the combined level of CRCs and dieldrin was ≥4.0 μg/g.

[d]DDT-related compounds (DDT, DDD, DDE); cases in which DDT + DDD/5 + DDE/15 ≥ 20 μg/g.

Table 2. Minimum prevalence[a] of organochlorine pesticide poisoning in selected bird species in New York, 2000-2004.

Species	n	No. Poisoned (%)
Sharp-shinned Hawk	124	2(1.6)
Cooper's Hawk	276	30(10.9)
Red-tailed Hawk	246	11(4.5)
American Kestrel	57	4(7.0)
Merlin	24	2(8.3)
Peregrine Falcon (*Falco peregrinus*)	36	0(0)
Bald Eagle (*Haliaeetus leucocephalus*)	57	0(0)
Screech owl	80	1(8.3)
Great Horned Owl	120	5(4.2)
Blue Jay[b]	291	17(5.8)
American Crow[b]	1780	22(1.2)

[a]Number of confirmed poisonings/ number of birds submitted for examination; analyses conducted only on birds in which the history and/or gross pathology suggested organochlorine poisoning

[b]Data for corvids restricted to 2001 when analyses were conducted on a much higher proportion of suspected poisonings than in other years.

intoxication. In eight cases, only the sum of OXY + HE + dieldrin exceeded 4.0 μg/g. Three American robins (*Turdus migratorius)* succumbed to DDT-related compounds (arithmetic mean ($\bar{x}$) DDT = 21.5 μg/g, $\bar{x}$ DDD = 5.1 μg/g, $\bar{x}$ DDE = 270 μg/g; analyses by Mississippi State).

The dominance of CRCs in the poisonings was consistent with previous findings in New York (Stone and Okoniewski 1988, Okoniewski and Novesky 1993) and New Jersey (Stansley and Roscoe 1999). Analysis of soils (Okoniewski and Novesky 1993, Stansley et al. 2001) indicate that previous applications to turfgrass are the principal source of CRCs in food chain contamination. In New York, historic turfgrass applications are also the most important source of dieldrin in some areas of the state. Previous applications to apple orchards are another important dieldrin source in New York (Stone unpublished). All three robins that succumbed to DDT-related compounds (DDTRs) were found in the vicinity of apple orchards.

Seventy-seven percent of the poisonings of non-raptors occurred in July. This is consistent with previous findings in New York (Okoniewski and Novesky 1993) where a peak in poisonings coincides with the emergence of Japanese beetles (*Popilla japonica*), European chafer beetles (*Rhizotragus majalis*), or other scarab beetles. The beetle emergence and the bird deaths appear to be connected by the presence of cyclodiene-resistant beetle populations (Tashiro and Neuhauser 1973, Tashiro et al. 1971). Levels of total CRCs as high as 15-18 μg/g have been measured in scarab beetles (Okoniewski and Novesky 1993, Stansley et al. 2001). The timing of raptor poisonings was more spread out although 71% of the

mortalities were recorded from July through September.

About two-thirds of the cases originated either on Long Island (24%), in New York City (15%), or in Westchester and Rockland Counties (28%) which flank the Hudson River just north of New York City. Although in part related to the number of submissions from this region, this statistic also probably reflects the historic pattern of chlordane use in New York. Of the remaining third of cases originating elsewhere in the state, 30% were from Monroe County (Rochester area) where dieldrin was once extensively used for the control of the European chafer beetle, and 26% were from Albany County (where our laboratory is located). The robins poisoned with DDTRs came from orchard settings (one in Clinton County, two in Columbia County) where DDTRs have been found in orchard soils in substantial amounts; i.e. 15-60 and 177-242 μg/g total DDTRs dry weight , Clinton Co., 2002, and Columbia Co.,1985, respectively (Stone unpublished).

Six American crows (*Corvus brachyrhynchos*), 1 blue jay (*Cyanocitta cristata*) , 1 Cooper's hawk (*Accipiter cooperi*) tested in 2000 and 2001 were both positive for WNV and had potentially lethal levels of CRCs (or CRCs + dieldrin). Had we not stopped testing WNV-positive birds, it seems likely that more such cases (mostly in WNV-vulnerable corvids) would have been recorded because WNV typically causes significant weight loss that would be accompanied by the mobilization and redistribution of OCs stored in fat.

Minimum prevalence of poisoning data at an annual statewide level (Table 2) provides an indication of the current impact of OC pesticides on populations of certain species breeding in or migrating through New York. The highest prevalence was in Cooper's hawks (11%, n = 275), a bird which frequently preys on medium-sized birds that are themselves vulnerable to the movement of OC pesticides through soil invertebrates; e.g. Northern flicker (*Colaptes auratus*), American robin, blue jay, and European starling (*Sturnus vulgaris*). The prevalence of cyclodiene poisoning in Cooper's hawks (11%) and Great horned owls (*Bubo virginianus*) (4%) in the present survey seemed less than that recorded during 1983-1992 (13%, n = 88; 7%, n = 481, respectively), but neither change was statistically significant.

In conclusion, these findings suggest that OC poisonings will continue to be a common cause of death in some avian species for years to come in New York other regions with similar soils, climate, fauna, and histories of pesticide use.

REFERENCES

Eidson E, Kramer L. Stone WB, Hagiwara Y, Schmit K, and The New York State West Nile Virus Surveillance Team (2001) Dead bird surveillance as an early warning system for West Nile Virus. Emerg Inf Dis 7:631-635

Okoniewski, JC, Novesky E (1993) Bird poisonings in suburbia: links to historic use on turf. J Wildl Manage 57:630-639
Stansley W, Roscoe DE (1999) Chlordane poisoning of birds in New Jersey, USA. Environ Toxicol Chem 18:2095-2099
Stansley W, Roscoe DE, Hawthorn E, Meyer R (2001) Food chain aspects of chlordane poisoning in birds and bats. Arch Environ Contam Toxicol 40:285-291
Stickel LF, Stickel WH, McArthur RD, Hughes DL (1979) Chlordane in birds: a study of lethal residues and loss rates. In: Deichmann WB (ed) Toxicology and occupational medicine. Elsevier, North Holland, New York, p 387
Stickel WH, Stickel LF, Coon FB (1970) DDE and DDD residues correlated with mortality of experimental birds. In: Deichmann WB (ed) Pesticides Symposia. Seventh Inter-American Conf Toxicol Occupational Med, Hale and Assoc, Inc., Miami, Florida, p 287
Stickel WH, Stickel LF, Spann JW (1969) Tissue residues of dieldrin in relation to mortality in birds and mammals. In: Miller MW, Berg GG (eds) Chemical fallout: current research on persistent pesticides. Charles C Thomas,Springfield, Illinois, p 174
Stone WB, Okoniewski JC (1988) Organochlorine pesticide-related mortalities of raptors and other birds in New York 1982-1986. In: Cade JJ et al. (eds) Peregrine falcon populations: their management and recovery. The Peregrine Fund Inc., Boise, Idaho, p 429
USEPA (1980) Manual of analytical methods for the analysis of pesticides in humans and environmental samples. EPA-600/8-80-038. USEPA Health Effects Research Laboratory, Research Triangle Park, NC
USEPA (1996) Test methods for evaluating solid waste, physical/chemical methods (SW-846), December 1996. USEPA, Office of Solid Waste and Emergency Response, Washington, DC
Tashiro H, Neuhauser W (1973) Chlordane-resistant Japanese beetle in New York. Search:Agriculture 3(3) (publication of the New York State Agric Exp Sta, Geneva)
Tashiro H, Personius KE, Zinter D, Zinter M (1971) Resistance of the European chafer to cyclodiene insecticides. J Econ Entomol 64:242-245