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Pesticide Residues in Guano of Gray Bats (*Myotis grisescens*) in Arkansas

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The gray bat, *Myotis grisescens*, is a small, insectivorous bat found in the karst regions of the southeastern United States. In the winter gray bats form a few extremely large colonies in cooler caves, while in the summer they disperse to more numerous caves over a large area, usually segregated by gender. Primarily due to population declines thought to be the result of excessive disturbance of these colony sites, the U.S. Fish and Wildlife Service placed the gray bat on the endangered species list in 1976 (Brady et al., 1982).

Subsequent to listing, gray bats in maternity caves in Missouri were killed by dieldrin (CAS # 60-57-1), a product of the insecticide aldrin (CAS # 309-00-2) (Clark et al., 1978). In addition to dieldrin, lethal levels of heptachlor epoxide (CAS # 76-44-8) were found in the brains of gray bats at other maternity sites (Clark et al., 1980, 1983a, 1983b). This mortality probably contributed to population declines observed at these caves, but it is difficult to determine the role of other factors such as human disturbance and normal population fluctuations.

Contaminants were most likely acquired by the bats while feeding on arthropods exposed to the pesticides following agricultural application (Clark et al., 1978, Clawson, 1989, 1991). The primary pesticide causing mortality, aldrin, was banned in 1974, and the chemical substituted for it, heptachlor, was made illegal in 1979, however these and the breakdown products of DDT, such as DDE, have been found to be extremely persistent in the environment (Clawson, 1991). Significant population declines of other bat species such as the Brazilian free-tailed bat (*Tadarida brasiliensis*) have also been traced to DDT poisoning including intentional applications of DDT to nursery colonies (Clark et al., 1978; Clark, 2001).

Although 1 prior study found that developing a statistically significant relationship between pesticide residues in bat guano and that in bat carcasses may not be possible, pesticide presence in guano is at least an indication that there may be more significant problems in the population. Samples taken from guano piles may represent a broad cross-section of the population as they include guano from large numbers of individuals; guano sampling also avoids the need to collect bat carcasses, which are often too decomposed for testing. Dieldrin concentrations in guano above 0.38 ppm have been found at caves where pesticide-related mortality has occurred (Clark et al., 1981).

The study was conducted at 4 gray bat caves in Arkansas: Bone and Dodd caves (Independence County),

Logan Cave (Benton County), and Morris Cave (Sharp County). Bone and Logan caves are both maternity colonies, and though Dodd Cave was a maternity colony in the 1970's (Saugey, 1978), since the early 1980s, it has only been used in the spring and fall. Morris Cave is a transient site used by gray bats in the spring. Guano from the upper layers of guano piles in these caves was collected in January (Logan Cave), February (Morris Cave), and April (Bone and Dodd caves), 2004 using a stainless steel spoon and kept at room temperature until tested. Four samples were taken in Bone, Dodd, and Logan caves, and 3 samples were taken from Morris Cave. Using electron capture gas chromatography the Mississippi State Chemical Laboratory (Mississippi State, MS) analyzed samples for the presence of 25 chemical compounds: HCB, alpha BHC, gamma BHC, beta BHC, delta BHC, oxychlordane, heptachlor epoxide, gamma chlordane, t-nonachlor, toxaphene, PCB - 1242, PCB - 1248, PCB - 1254, PCB - 1260, PCB - Total, o,p'-DDE, alpha chlordane, p,p'-DDE, dieldrin, o,p'-DDD, endrin, cis-nonachlor, o,p'-DDT, p,p'-DDD, and mirex.

Thirteen of 15 (87%) samples contained p,p'-DDE with values ranging from 0.011 to 0.057 ppm (dry weight). This breakdown product of DDT was found in samples from every cave whereas dieldrin was found in only 2/15 (13%) samples (Table 1). Dieldrin concentrations at Bone and Dodd caves were 0.012 and 0.014 ppm respectively in the two samples in which dieldrin was detected. The remaining 23 compounds were not found in any samples.

This study confirms that gray bats in Arkansas caves have been and are continuing to be exposed to pesticide residues that are potentially fatal. However, the pesticide concentrations found in guano from this small sample of Arkansas maternity caves are low in comparison to those found in previous studies (Table 2). Dieldrin was found at 2 caves at low concentrations. Levels of dieldrin previously associated with bat mortality (> 0.38 ppm) are 27 times higher than the most contaminated sample observed in Arkansas, and heptachlor epoxide was not found in any of the samples. Though there is a less reliable relationship between DDE and bat mortality, that it was present in all caves indicates that it could have played a role in bat deaths in the past.

Despite the ban on the use of DDT and dieldrin in the 1970s, the pesticide residues found in this study are still commonly detected in surface and groundwater samples in the Ozarks (Adamski and Pugh, 1996; Bell et al., 1996; Adamski, 1997; Bell et al., 1997). Pesticides continue to play

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an important role in agriculture and their use is increasing in the study area. Though harvested cropland represents only 5-18% of the land base in Benton, Independence, and Sharp counties, there has been a sharp increase in the use of pesticides in recent years. From 1997 to 2002 there was a 240% increase in land treated with chemicals to control insects, weeds, grass, brush, nematodes, and diseases in crops and orchards in Benton County. Independence County and Sharp County had smaller increases of 6% and 21% over the same period (U.S. Department of Agriculture, 2004).

In conclusion, given the continuing influence of banned pesticides and the increasing use of new compounds in agriculture in the region, periodic monitoring of pesticide concentrations in guano and carcasses of dead bats is recommended.

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Table 1. Contaminants detected (ppm by dry weight) in gray bat guano in Arkansas, 2004.

CAVE	SAMPLE #	p,p'-DDE	Dieldrin
Bone Cave (Independence Co.)	1	0.028	ND*
	2	0.037	0.012
	3	0.036	ND
	4	0.032	ND
	Average	0.033	n/a
Dodd Cave (Independence Co.)	1	0.015	ND
	2	ND	ND
	3	0.040	0.014
	4	0.020	ND
	Average	0.019	n/a
Logan Cave (Benton Co.)	1	0.057	ND
	2	ND	ND
	3	0.033	ND
	4	0.051	ND
	Average	0.035	n/a
Morris Cave (Sharp Co.)	1	0.015	ND
	2	0.011	ND
	3	ND	ND
	Average	0.009	n/a

*ND = Not Detected

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Table 2. Comparison of three contaminants found in guano by this and other studies.

Study	DDE		Dieldrin		Heptachlor epoxide	
	% colonies in which found	Range (ppm) (dry)	% colonies in which found	Range (ppm) (dry)	Range colonies in which found	% (ppm) (dry)
Virginia –Historic Ryan et al. 1992 (n = 2)	100	0.08-0.63	100	0.08-0.46	50	0.25
Alabama –1976 Clark et al. 1988 (n = 8)	100	0.122-1.563	75	2.632 - 10	38	2.44 – 6.667
Alabama –1985 Clark et al. 1988 (n = 1)	100	0.5	0	n/a	0	n/a
Missouri –1982 Clawson 1989 (n = 4)	–	–	75	0.31-0.61	25	0.15
Missouri -1988-89 Clawson 1991 (n = 5)	–	–	100	Note 1	100	Note 1
Virginia –1989 Ryan et al. 1992 (n = 3)	67	0.03-0.04	0	n/a	0	n/a
Oklahoma –1990 Martin 1992 (n = 5)	100	0.05-0.14	0	n/a	0	n/a
Arkansas – 2004 This study (n = 4)	100	0.011-0.057	50	0.012- 0.014	0	n/a

Note 1 = Insufficient information is available to transform reported contaminant values to be directly comparable with other studies.

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