Bull. Environ. Contam. Toxicol. (1990) 44:73–80

Bulletin of Environmental Contamination and Toxicology

Survival of Northern Bobwhites in Georgia: Cropland Use and Pesticides

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The long-term subtle effects on avian populations of persistent organochlorine pesticides, such as DDT and dieldrin, have been well documented (Anderson and Hickey 1972; Blus et al. 1974; King et al. 1980). Use of some of these chemicals in the United States has been restricted or banned and others are under close scrutiny. Organophosphorus (OP) or carbamate (CA) compounds are favored for field application because they are quick-acting, relatively short-lived, and do not accumulate in food webs (Stickel 1974); certain of these are extremely toxic, and reports of bird kills associated with short-term exposure are common (Smith 1987). However, the cumulative effects of OP's and CA's over an entire spray season on local avian populations in agricultural areas are poorly understood.

Our objectives were to quantify cropland use and survival of an avian species in an agricultural area receiving repeated pesticide applications, mainly OP's. We chose the Northern bobwhite (Colinus virginianus) for study because they occur in edge habitats adjacent to croplands (Rosene 1969), they are easily trapped and have small home ranges, and the population in Georgia has been declining for decades (Simpson 1976), possibly as a result of pesticide exposure as seen in grey partridge (Perdix perdix) in England (Potts 1986). Comparison of bobwhite survival on sprayed and unsprayed farms of similar composition would have been ideal, but no unsprayed farms were located. However, weather conditions allowed us to compare survival on a farm in a drought year (1986) when few pesticides were applied, with that in a normal-rainfall year (1987) when repeated applications were needed.

MATERIALS AND METHODS

The study site was Wildmeade Plantation near Leary, Calhoun County, Georgia (31°30'N, 84°31'W), comprising about 2,023 ha of pine (Pinus spp.)-hardwood forest interspersed with cropland and planted pine strips. Major row crops (≥20 ha) that are rotated yearly include peanuts, corn, and cotton. In 1986, about 120 ha

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were in peanuts and 80 ha in corn; in 1987, about 95 ha were in peanuts, 50 ha in corn, and 20 ha in cotton. About 245 ha are in cultivated pecan orchards. Minor row crops (<20 ha) include wheat, sorghum, and sunflowers. Under normal climatic conditions, crops including pecans are sprayed repeatedly during summer months with various insecticides.

During early March-mid April 1986 and 1987, native Northern bobwhites were trapped, aged, leg-banded, and outfitted with ≤5-g backpack radio packages with expected transmittance lives of 6 months. Birds were captured with funnel traps placed in corn-baited areas where bobwhite sign was evident. Instrumented birds were immediately released at their capture site. We radio-tagged 75 bobwhites (7 adult males, 6 adult females, 14 subadult males, 48 subadult females) in 1986 and 207 (53 adult males, 40 adult females, 51 subadult males, 63 subadult females) in 1987. No birds died from stress during handling. Birds were monitored daily through August (except weekends) each year. Several (3-5) staggered telemetric readings using triangulation were obtained per day for each bird, and birds were flushed weekly to see if they were flying well. Locations were plotted on 1:24,000 topographic maps of the study area. Date, time, distance to nearest crop, crop type, and general habitat type were recorded for each reading. The farm managers at Wildmeade Plantation kept us informed of chemical materials and application rates and dates for each crop throughout the study period. Pesticide applications began in late May each year and occurred through late June in 1986 and late August in 1987.

Daily monitoring of birds began in late April each year; therefore, birds that died or were lost due to radio failure, radio loss, or emigration from the study area before this period were not included in the survival analyses (Pollock et al. 1989). Survival estimates were calculated and distributions were compared within and between years using the Kaplan-Meier (1958) procedure and log rank test as described and modified by Pollock et al. (1989). The proportions of cropland use were calculated by dividing the number of observations birds were in, or ≤100 m of, a particular crop type by the total number of observations obtained.

RESULTS AND DISCUSSION

Bird use of croplands and adjacent areas varied widely between years and crop types (Table 1). Most of the time (>60%), birds associated with crops were found either in or ≤100 m of a particular crop type, except in 1987 when a majority (59.5%) of birds around peanuts were >100 m from the fields. Birds never were located in sorghum fields in 1986, but birds associated with sorghum in 1987 were in the fields more than half the observations. Cotton was grown only in 1987, and only 1 bird was found within field margins; the majority (60.4%) of birds were found ≤100 m of field edges. Sunflowers were grown only in 1987,

Table 1. The distribution of 8,527 telemetric observations of Northern bobwhites relative to nearest crop at Wildmeade Plantation, southwestern Georgia, 1986 and 1987.

Nearest crop	n[a]	In crop (%)	≤100 m (%)	>100 m (%)
1986				
Peanuts	279	9.3	68.5	22.2
Pecans	1,477	18.1	62.5	19.4
Corn	85	31.8	40.0	28.2
Wheat	148	45.3	41.9	12.8
Sorghum	50	0.0	72.0	28.0
1987				
Cotton	730	0.1	60.4	39.6
Peanuts	3,508	1.3	39.2	59.5
Pecans	1,324	17.8	63.7	18.5
Corn	733	21.4	53.4	25.2
Sunflowers	32	31.3	46.8	21.9
Wheat	103	34.9	61.2	3.9
Sorghum	58	51.7	46.6	1.7

[a] Number of observations that a particular crop was the nearest crop to a bird's location.

but association with sunflowers was infrequent (<0.5% of total observations).

Organophosphorus chemicals were the principal type used at Wildmeade Plantation during the study (Tables 2, 3). Because of the extreme drought in Georgia in 1986, pecan orchards were sprayed only twice, compared to 7 times in 1987, a near-normal rainfall year (W. A. Dorough, pers. commun.). Peanuts received 4 applications each year, but the combination of chemicals used differed between years. Cotton, grown only in 1987, received weekly applications during 1 July-25 August, but sunflowers were

Table 2. Pesticide applications by crop type at Wildmeade Plantation, southwestern Georgia, 1986.

Crop (ha)	Spray date	Pesticide (type)[a]	L/ha	Method
Peanuts (120)	6/19	chlorpyrifos (OP)	1.16	aerial
	6/24	methomyl (CA)	1.75	aerial
	8/2	acephate (OP)	0.24	aerial
	8/22	methomyl	1.75	aerial
Pecans (245)	5/28	phosalone (OP)	2.34	blower
	6/18	phosalone	2.34	blower

[a] OP = organophosphorus, CA = carbamate.

Table 3. Pesticide applications by crop type at Wildmeade Plantation, southwestern Georgia, 1987.

Crop (ha)	Spray date	Pesticide (type)[a]	L/ha	Method
Peanuts (95)	6/10	dimethoate (OP)	1.16	blower
	6/25	chlorpyrifos (OP):	1.16:	blower
		methomyl (CA)	1.75	
	7/22	methomyl	1.75	aerial
	8/19	methomyl	1.75	aerial
Pecans (245)	5/19	phosalone (OP)	2.34	blower
	5/22	phosalone	2.34	blower
	5/26	phosalone	2.34	blower
	7/9	phosalone	2.34	blower
	7/21	endosulfan (OC)	2.34	blower
	8/24	phosalone	3.50	blower
	8/26	methomyl:	4.67:	blower
		disulfoton (OP):	1.75:	
		carbaryl (CA)	11.67	
Cotton (20)	7/1	methyl parathion (OP):	0.58:	blower
		chlordimeform (OC)	0.29	
	7/10	methyl parathion:	0.58:	blower
		chlordimeform	0.29	
	7/22	methyl parathion	0.58	blower
	7/28	methyl parathion	0.58	blower
	8/5	chlordimeform:	0.29:	blower
		chlorpyrifos	0.58	
	8/17	chlordimeform	0.29	blower
	8/25	methyl parathion	1.16	aerial
Sunflowers (6)	5/26	methomyl	1.75	blower

[a] OP = organophosphorus, CA = carbamate, OC = organochlorine.

sprayed only once early in the season (Table 3). Neither corn, wheat, nor sorghum received pesticide applications.

Before daily monitoring began in late April, 21 birds died or disappeared in 1986 and 53 in 1987; this reduced the number of birds on day 1 of the monitoring period to 54 and 154, respectively. The proportion of birds that disappeared (41%) during the 18-week period in 1986 was similar (χ^2 = 0.04, 1 df, P = 0.975) to that for deaths (39%), but in 1987 a greater (χ^2 = 38.71, 1 df, P = 0.001) proportion of birds died (55%) than disappeared (21%). Also, the proportion of birds that disappeared in 1986 was greater (χ^2 = 8.29, 1 df, P = 0.004) than that for 1987, but the reverse was true for mortality--a larger (χ^2 = 4.25, 1 df, P = 0.042) percentage of birds died in 1987 than in 1986.

Overall, survival distributions for the entire 18 weeks were similar (χ^2 = 0.99, 1 df, P = 0.363) between years (Fig. 1). Heavy mortality lowered survival estimates considerably between weeks 10 and 14 in 1987; during that time, 39% (37/95) of those birds at risk died, compared to only 7% (2/27) in 1986. In contrast, only 9% (9/95) of the birds disappeared during weeks 10-14 in 1987, compared to 30% (8/27) in 1986. Because of this heavy mortality, survival during weeks 10-18 in 1987 was significantly lower (χ^2 = 4.93, 1 df, P = 0.036) than in 1986 (Fig. 1).

Crops in 1986 received only 6 applications, compared to 19 in 1987. Heavy mortality recorded during weeks 10-14 in 1987 closely paralleled 7 OP and CA pesticide applications, 3 to peanuts and 4 to cotton (Table 3). Peanuts and cotton were the nearest crops to death sites of 60% (22/37) of the birds that died during this period. Because none of the remains found were suitable for brain cholinesterase (ChE) or pesticide analyses, which would confirm death from OP or CA toxicity (Hill and Fleming 1982), we advise caution in interpreting these results. Also, some birds may have died indirectly from sublethal exposure, thereby making them more susceptible to predation or starvation (White et al. 1983).

Chlorpyrifos and methomyl used on the peanuts and methyl parathion on the cotton were highly toxic to birds in acute oral LD_{50} tests (Hudson et al. 1984), and all have been implicated in wild bird die-offs (Smith 1987). Phosalone and endosulfan were each sprayed once on pecan trees during weeks 10-14, but it is unlikely that they contributed to mortality; only 1 death was recorded near pecan groves during that period. Although phosalone and endosulfan were moderately toxic to birds in acute oral toxicity tests (Worthing 1979; Hudson et al. 1984), no adverse effects from field applications have been reported (Smith 1987). Our results support this contention.

Bobwhites are known to frequent agricultural fields and borders (Hunter 1954; Rosene 1969; Eubanks and Dimmick 1974; Exum et al. 1982), but this is the first study to quantify the use of croplands by bobwhites over a spray season. Our radioed birds were found in or ≤100 m of crops most of the time (>60%), so the potential for exposure to pesticides applied to crops was great. We were unable to collect bobwhites for brain ChE determination, a measure of OP or CA toxicity (Ludke et al. 1975), but methyl parathion applied to cotton fields in North Carolina inhibited ChE activity in bobwhite brains, ranging up to 68.3% (Smithson and Sanders 1978); inhibition ≥50% in birds may be diagnostic for cause of death (Ludke et al. 1975). In a separate study at Wildmeade Plantation, 11 of 15 blue jays (Cyanocitta cristata) collected in pecan groves 6 hr after a disulfoton spray (0.83 kg/ha) had moderate to severe brain ChE inhibition, ranging from 32 to 72% (White, unpublished data). Other field studies have demonstrated ChE inhibition in birds after OP or CA sprays (Busby

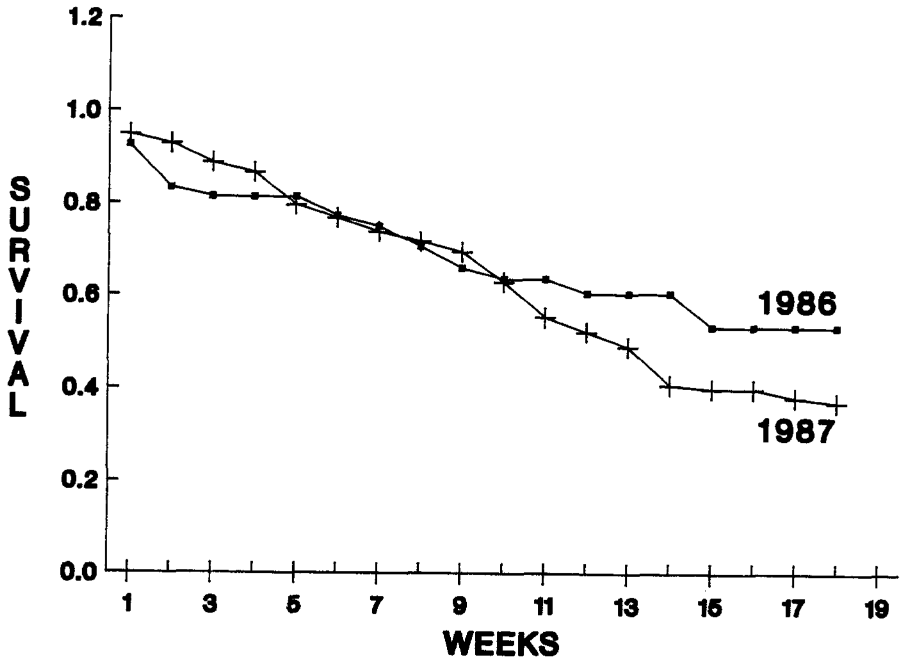

Figure 1. Yearly survival distributions of radio-tagged Northern bobwhites at Wildmeade Plantation, southwestern Georgia.

et al. 1983; Zinkl et al. 1980), and some have reported heavy mortality from anticholinesterase poisoning after sprays (Seabloom et al. 1973; DeWeese et al. 1981).

It was impossible to determine the causes of mortality in this study, although 3-5 telemetric readings were obtained each day for birds. Usually, by the time we discovered that a bird was immobile, all we found was the radio, sometimes a few feathers, and, rarely, body parts, such as feet and wing tips. Only twice in 1986 and 8 times in 1987 were intact carcasses found, and all of these had been attacked by fire ants (Solenopsis invicta); none were suitable for necropsy or pesticide analysis. Bird carcasses experimentally placed in agricultural fields disappeared rapidly, many within 24 hours, presumably removed by predators or scavengers (Rosene and Lay 1963; Balcomb 1986). We believe that similar fates befell most of our birds. Mortality switches on our radios may have enabled us to find dead birds sooner, but because of the required small size of our units (≤5 g), this was not possible. We do not believe our radio packages influenced bobwhite survival; the units averaged only 2.8% of body weight at time of instrumentation, almost identical to that in an Alabama study where radios caused no losses (Speake and Sermons 1986). Only a few of our birds (<10) had difficulty flying upon release; when flushed later, all survivors appeared to fly normally. Transmitters weighing 14 g may have influenced bobwhite survival in a winter telemetry study (Yoho and Dimmick 1972).

Acknowledgments. We are grateful to H. A. Shepard, owner of Wildmeade Plantation, for access to his property. Special thanks go to W. A. Dorough and L. B. DeBary of the Wildmeade staff for their logistical support and cooperation. K. L. Ensor, D. M. Kavanaugh, and R. G. Rumph assisted in field work. D. R. Clark, Jr., E. L. Flickinger, F. S. Guthery, and K. L. Stromborg reviewed the manuscript, C. M. Bunck and K. A. Patnode provided statistical assistance, and B. J. Fancher typed the manuscript.

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Received March 28, 1989; accepted June 27, 1989.