THE PACKSADDLE WILDLIFE MANAGEMENT AREA EXPERIMENT

STEPHEN J. DEMASO, Upland Game Biologist, Oklahoma Department of Wildlife Conservation, 1801 N. Lincoln, Oklahoma City, OK 73105

SCOTT A. COX, Wildlife Research Technician, Oklahoma Department of Wildlife Conservation, P.O. Box 633, Cheyenne, OK 73628

EDWARD S. PARRY, Wildlife Technician, Oklahoma Department of Wildlife Conservation, 909 E. Balsom, Fredrick, OK 73542

ALAN D. PEOPLES, Assistant Chief, Oklahoma Department of Wildlife Conservation, 1801 N. Lincoln, Oklahoma City, OK 73105

Abstract: We investigated survival and cause-specific mortality of 1,115 radiomarked northern bobwhites (*Colinus virginianus*) and the effect of supplemental feeding on these population parameters. Research was conducted from 1 October 1991 through 1 October 1996 on the Packsaddle Wildlife Management Area (WMA) in western Oklahoma. Thirty-two feeders filled with sorghum were located near the center of every 20 acres on the 700 acres treatment area. The control treatment was 700 acre and contained no quail feeders. Annual survival on the control area was 17.9% and 21.0% on the feeder area. Annual survival pooled over areas was 19.8%. Four-hundred-seventy-seven mortalities occurred on the control treatment and 433 mortalities on the feeder treatment. Avian and mammalian predators, and hunting were the primary mortality agents. Direct mortality due to weather was low and no birds died from disease. Mean annual mortality rates were 82.1% on the control area, 79.0% on the feeder area, and 80.2% pooled over areas. Supplemental feeding did not have an effect on annual bobwhite survival or mortality, but did affect the distribution of cause-specific bobwhite mortality. Line-transect flush counts were used to annually collect data on covey size and density on each area. Transects were traversed on horseback during October and March of each year. Mean fall covey size was similar between the control (14.0 birds/covey) and treatment (14.2 birds/covey) areas. Mean spring covey size was similar between the control (9.4 birds/covey) and treatment (6.6 birds/covey) areas. Mean bobwhite density was similar between control (0.52 birds/acre) and treatment (0.56 birds/acre) areas. We concluded that quail feeders had no effect on mean covey size or density of bobwhite populations in western Oklahoma.

Introduction

Supplemental feeding is commonly used in Oklahoma and throughout the bobwhite's range in an attempt to augment bobwhite populations (Frye 1954, Guthery 1986:48, Peoples 1992). Few studies have examined the effect of supplemental feeding on wild bobwhite populations (Frye 1954, Peoples 1992) and they provide conflicting results. Frye (1954) reported an increase in bobwhite numbers from supplemental feeding in south Florida. In Kansas, Robel et al. (1979) found bobwhites had lower weights, lower fat content, and increased mortality when supplemental feed was not available during winter. Supplemental feeding may increase survival during stressful periods (i.e., severe winter weather and drought) and increase productivity if applied properly (Guthery 1986:48).

Survival of bobwhites has been estimated by differences between fall and spring population surveys (Dimmick et al. 1982, Roseberrry and Klimstra 1984), covey counts (Kabat and Thompson 1963), age-ratio information (Marsden and Baskett 1958, Roseberry and Klimstra 1984), and radio telemetry (Curtis et al. 1988, Burger et al. 1995). Radio telemetry allows direct determination of survival and mortality of individuals, thereby permitting estimation of survival functions and associated variances (Pollock et al. 1989*b,c*). Estimates of survival using radio telemetry assume that the behavior and survival of radiomarked individuals is similar to that of unmarked individuals. Survival rates of northern bobwhites on supplementally fed and control areas are lacking in the literature.

Estimates of cause-specific mortality have been reported for few bobwhite populations (Burger et al.

1995). Adult bobwhite sex ratios are skewed toward males (Roseberry and Klimstra 1984:136). There are competing hypotheses regarding sources and timing of differential mortality that cause sex-ratio bias. Stoddard (1931:94) suggested that females have lower winter survival; Pollock et al. (1989*a*), Shupe et al. (1990), and Roseberry and Klimstra (1992) reported higher female harvest rate; and Leopold (1933), Buss et al. (1947), and Bennitt (1951) suggest that females experience higher mortality during incubation. Mortality of northern bobwhites on areas with and without supplemental feed and control areas are absent in the literature.

Bobwhite management has operated under the assumption that more food results in better habitat; this is why many bobwhite management programs use supplemental feeding, food plots, strip discing to promote annual forbs, and prescribed burning. If food is the limiting factor then practices aimed at increasing food should also increase bobwhite density. Guthery (1997) analyzed data collected by Frye 1954, Keeler 1959, Doerr 1988, and Kane 1988. His analysis showed that the mean autumn density on control sites was similar to that on fed sites. Guthery (1997) concluded that food suplementation is a neutral management practice.

Study Area

Research was conducted on the Packsaddle WMA in southern Ellis county, Oklahoma. Cole et al. (1966) described the soils, ecological, and climatic conditions in the county. DeMaso et al. (1997) provide details on the Packsaddle WMA study area. Soils in the area include Nobscot fine sand, Nobscot-Brownfield, and

Pratt-Tivoli loamy fine sand. Grasses on these soils were sand bluestem (*Andropogon hallii*), little bluestem (*A. scoparius*), indiangrass (*Sorghastrum nutans*), switchgrass (*Panicum virgatum*), sand paspalum (*Paspalum stramineum*), blue grama (*Bouteloua gracilis*), hairy grama (*B. hirsuta*), and sand dropseed (*Sporobolus cryptandrus*). Forb species included western ragweed (*Ambrosia psilostachya*), Texas croton (*Croton texensis*), erect dayflower (*Commelina erecta*), and prairie sunflower (*Helianthus petiolaris*). Woody vegetation included shinnery oak (*Quercus harvardii*), sand sagebrush (*Artemisia filifolia*), and sand plum (*Prunus angustifolia*) (Cole et al. 1966).

The study area was divided into 2 areas, each about 700 acres. One area was supplemented with milo *ad libitum* in gravity-flow feeders, distributed at about 1 feeder/20 acres. The second area served as a control, and was separated from the feeder area by a 0.75 mile wide buffer zone.

Methods

Trapping

We trapped bobwhites in baited funnel traps (Stoddard 1931:442, Wilbur 1967) during the entire study period (1 October 1991 to 1 October 1996). Additional birds were caught throughout the study period by netting roosting coveys (Labisky 1968). Bobwhites were classified by age and sex (Rosene 1969:44-54). Captured bobwhites were fitted with a leg band and a radio transmitter weighing <0.2 ounces. Radio transmitters were only placed on bobwhites ≥6 weeks old. Necklace-style transmitters were similar to those described by Shields et al. (1982). However, some transmitters had an adjustable neck loop, an adjustable body loop, a mortality sensor, and a ≤10.2-inch antenna (Holohil Systems Ltd., Carp, Ont.; Wildl. Materials Inc., Carbondale, Ill.).

We located birds ≥5 days/week using hand-held 3-element yagi antennas. Occasionally, aircraft were used to locate widely dispersed individuals. Radiomarked bobwhites were approached on foot until radio signal strength indicated the observer was about 20 m from the adult, and the bird was then circled to determine an exact location. When a mortality signal was detected, transmitters were immediately located and the proximate cause of mortality was determined from evidence at the recovery site and condition of the transmitter (Dumke and Pils 1973). When we recovered an entire bird and the cause of mortality could not be identified, the bird was sent to the Oklahoma Animal Disease Diagnostic Laboratory at Oklahoma State University, Stillwater for necropsy.

Survival Rates

We calculated mean daily survival rates by month for the entire study period. We used the Kaplan-Meier method (Kaplan and Meier 1958) to estimate mean daily survival rates by month, generalized to the staggered entry case (Pollock et al. 1989*b,c*). Birds had to survive ≥7 days after radiomarking to ensure survival probabilites were not biased by trapping or handling (Pollock et al. 1989*b,c*; White and Garrott 1990).

Birds that survived the entire month were

reintroduced as a new independent observation at the beginning of the next month. We reintroduced birds that had been censored and were recaptured and radiomarked again as new independent observations.

Rates and Causes of Mortality

Mortalities were assigned to 1 of 6 classes. Classes included 1) avian, 2) mammal, 3) hunting, 4) weather, 5) unknown, and 6) other. The other category included birds that survived ≥7 days, but were found dead in traps or birds that died due to the radio package.

Species of avian predators commonly found at the Packsaddle WMA include Cooper's hawks (*Accipiter cooperii*), sharp-shinned hawks (*A. striatus*), red-tailed hawks (*Buteo jamaicensis*), and northern harriers (*Circus cyaneus*). Species of mammalian predators found on the area include bobcats (*Lynx rufus*), coyotes (*Canis latrans*), gray foxes (*Urocyon cinereoargenteus*), raccoons (*Procyon lotor*), swift fox (*Vulpes velox*), and striped skunk (*Mephitis mephitis*).

We estimated cause-specific mortality rates by month for the entire study period. We used the computer program MICROMORT which uses the Heisey-Fuller method (Heisey and Fuller 1985) to estimate mean daily survival rates by month, generalized to the staggered entry case (Pollock et al. 1989*b,c*).

Cause-specific mortality rates are presented as the probability of an animal dying during a given interval due to a specific mortality agent, given that other competing mortality agents were present (Heisey and Fuller 1985). The Heisey-Fuller approach makes the same assumptions as Kaplan and Meier (1958), that daily survival rate is constant within an interval and that each animal radio-day is an independent event.

Bobwhite Density

Bobwhite density was estimated using line-transect methodology (Burnham et al. 1980, Buckland et al. 1993). Four 0.5 mile long transects were permanently established on each study area, 0.3 mile apart, and oriented north-south. Transects were traversed on horseback repeatedly during the first and last 3 hours of daylight (Guthery 1988) until cumulative length ridden was 20 miles/site per season. Each time a covey flushed, the number of birds and right-angle distance from the transect to the point where the covey flushed were recorded.

Line-transect data were used to estimate density using the computer program DISTANCE (Buckland et al. 1993). The half-normal detection model was used because it satisfies the model criteria of a low AIC, chi-square tests indicated that the data fit the model, and the shape of the detection function had the broadest shoulder (Buckland et al. 1993).

Results

We radiomarked 1,115 bobwhites that survived ≥7 days; 579 birds on the control area and 536 on the feeder treatment. Three hundred and nine birds were radiomarked, but survived ≤7 days. We right-censored 214 (19.2%) observations because radio failure or battery expiration (55) and birds that slipped their radiotransmitters (159).

Survival Rates

Mean monthly daily survival rates (n = 5 years/month) were higher on the feeder area during February, March, May, October, November, and December (Table 1). During February mean monthly daily survival rates differed between the feeder area and the control area (Table 1). However, the P-value was just barely significant. Average annual survival of bobwhites on the control area was 17.9% and 21.0% on the feeder area. Annual survival pooled over areas was 19.8%.

Rates and Causes of Mortality

We estimated cause-specific mortality rates from 910 observed mortalities of 1,115 radiomarked bobwhites.

Four-hundred-seventy-seven mortalities were observed from 579 radiomarked bobwhites on the control treatment and 433 mortalities were observed from 536 radiomarked bobwhites on the feeder treatment. Raptor, mammal, and hunting were the primary mortality agents on both areas (Fig. 1). Direct mortality due to weather was low on both areas. No birds died because of disease.

Unknown mortality was different among years. Raptor and hunting mortalities pooled over years differed among months (Fig. 1). Mortality rates pooled over years differed between adult and juvenile bobwhites during October and November. Pooled over months and years, mammal, hunting, and unknown mortalities differed between adults and juveniles. Mortality rates pooled over years differed between

female (M = 0.069) and male (M = 0.099) bobwhites only in May. During May, avian mortality was higher on males (M = 0.047) than females (M = 0.020).

Pooled over years, mortality differed between the control and feeder area during January (Control = 0.24, Feeder = 0.26), February (Control = 0.22, Feeder = 0.14), and December (Control = 0.25, Feeder = 0.21) (Fig. 1). Cause-specific mortality rates differed between treatments for mammalian (Control = 0.23, Feeder = 0.17) and other mortality (Control = 0.08, Feeder = 0.02) when pooled over months and years (Fig. 1). Mean annual mortality rates were 82.1% on the control area, 79.0% on the feeder area, and 80.2% pooled over areas.

Bobwhite Density

Mean fall covey size was similar between the control (14.0 birds/covey) and treatment (14.2 birds/covey) areas (Table 2). Mean spring covey size was similar between the control (9.4 birds/covey) and treatment (6.6 birds/covey) areas (Table 2). Mean covey size was similar among years, but differed between spring (7.6 birds/covey) and fall (14.1 birds/covey) seasons (Table 2). Mean bobwhite density was similar between the control (0.52 birds/acre) and treatment (0.56 birds/acre) areas.

Discussion

Survival Rates

The annual survival rate of our sample (19.8%) was similar to that reported in studies using age-ratio and count data (18.0%, Marsden and Baskett 1958; 15.4%, Kabat and Thompson 1963:36; 18.8% based on age-ratios, 18.2% based on the product of fall-spring and spring-fall survival rates, Roseberry and Klimstra 1984:89). Our estimate was higher than that reported by other radio telemetry studies of bobwhite survival. Burger et al. (1995) estimated annual survival of bobwhites in northern Missouri to be 5.3%. Curtis et al. (1988) estimated annual survival to be 6.1% for bobwhites in North Carolina. Curtis et al. (1988) reported a higher survival (25.7%) for a unhunted, radiomarked sample in Florida. Pollock et al. (1989*a*) estimated bobwhite annual survival (16.7%) in Florida using band recovery models.

Differences between our estimates and those reported in the literature may be due to differences in techniques, locations and/or time, and climate. The effect of radio transmitters on bobwhite survival needs further investigation.

We were unable to find any other studies that researched the effect of quail feeders on survival. Our data suggest that supplemental feeding has little or no effect on the survival of northern bobwhites in western Oklahoma.

Rates and Causes of Mortality

Predation was the primary cause of bobwhite mortality. Overall rates and causes of mortality were similar to the results of other studies in Illinois (Roseberry and Klimstra 1984), southern Alabama (Sermons 1987), North Carolina (Curtis et al. 1988), northern Florida (Mueller et al. 1988), and northern Missouri (Burger et al. 1995). However, our estimate of annual mortality is lower than what is reported for other bobwhite telemetry studies (Curtis et al. 1988, Burger et al. 1995). Our observations of high avian predation during the fall and increased mammalian predation during the spring are consistent with Curtis et al. (1988) and Burger et al. (1995). Our data suggest that cause-specific mortality was similar between feeder and control areas, except for mammalian predation which was higher on the feeder area. We could not find any other estimates of cause-specific bobwhite mortality on supplementally fed areas in the literature.

We feel that quail feeders tended to concentrate quail around feeders, thus increasing predation when food was limiting during the 5 year study period. During our study, hunting mortality was higher on the feeder area (M = 0.21) than on the control area (M = 0.17). This may be because quail were concentrated around feeders and were found easier by hunters. Quail feeders may be beneficial in the context of a commerical hunting operation.

We did not find any mortalities caused by disease. Our data do not support the hypothesis (Guthery 1986:54) that quail feeders may augment the transmission of avian diseases (through ingestion of diseased birds feces, while feeding) by concentrating bobwhites around quail feeders.

Bobwhite Density

Mean covey size did not differ between the control and treatment area among years. This was similar to the results from a quail feeder study in Alabama (Keeler 1959). We were unable to find any other studies that reported the effect of quail feeders on mean

covey size.

We found no difference in bobwhite density between the control and treatment study areas. Our results are consistent with studies in south Texas (Doerr 1988, Kane 1988, Guthery 1997) and in Alabama (Keeler 1959). However, Frye (1954) reported an increase in bobwhite numbers on an area with automatic quail feeders in south Florida. We agree with Guthery (1997) that food supplementation is a neutral management practice.

Four assumptions must be met in order for a supplemental feeding program for bobwhites to be successful (Doerr 1988). They include: 1) the native food supply is limiting bird numbers, 2) no other habitat parameter (i.e., nesting cover, brood-rearing cover, woody cover, etc.) restricts the population from increasing when supplemental food is provided, 3) birds will utilize supplemental feed, and 4) the birds will be healthier (have higher survival, be more productive, avoidance of predators, etc.) when the food supply is improved (Doerr 1988). On an annual basis some of the above assumptions may not be met on native rangeland in western Oklahoma.

Our results and the results of other researchers show that increasing food does not increase bobwhite covey size or densities. However, supplemental feeding may be useful as a shooting preserve management tool. Doerr (1988) found that of the birds collected in south Texas, there was a tendency to find birds close to feeders more often than at points without feeders. Data from Packsaddle WMA controlled hunts showed similar results early during hunting season. For years the apparent benefits of supplemental feeding in managing shooting preserve quail has confused the quail hunting public into thinking that feeding is a good wildlife management practice for wild quail.

Management Implications

Although bobwhite populations have declined in Oklahoma, our research suggests that food availability is not the cause of the decline. Supplemental feeding of bobwhites in western Oklahoma did not increase survival or the number of birds on the feeder area. Avian predation of bobwhites was higher on the feeder area.

Bobwhite managers should focus management activities on habitat manipulation. Management activities such as prescribed burning, strip discing, and cattle grazing can be used to augment the late fall and winter supply of bobwhite food. Also, these techniques can increase the amount of insects available to bobwhites during the spring and summer. These activities should take place in close proximity ($\leq$100 yards)to woody (escape) cover to minimize predation.

The decline of the bobwhite throughout its range is a complex problem. Many factors may be responsible for suppressing bobwhite numbers, however, it is unlikely that any one individual factor is cause for the decline. Further research is needed to understand these factors, their mechanisms, and dynamics that are responsible for bobwhite population fluctuations.

Future Bobwhite Research at Packsaddle Wma

Bobwhite chick ecology is the least understood part of the bobwhite's life history. Bobwhites lay large clutches, may renest multiple times, and male bobwhites may share the responsibility of incubating the nest and caring for the chicks with the hen. Bobwhite reproduction may respond to population density, weather, habitat availability, and physical condition of the breeding adults. Problems associated with studying wild bobwhite chicks include the ability to detect and count chicks, weather, and habitat where chicks are found. Continuous observations of marked chicks would appear to be the most reliable method, but marking chicks could negatively influence chick survival. The effect of marking chicks on survival remains untested.

The Oklahoma Department of Wildlife Conservation (ODWC) initiated a study of bobwhite chick ecology in the fall of 1996 in an attempt to better understand the ecology of bobwhite chicks. The goals of this study are to monitor survival and causes and rates of bobwhite chick mortality using micro radio transmitters, and examine the reproductive success of adult bobwhites. The field work for this study began October 1, 1996.

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Table 1. Mean monthly daily survival rate estimates (s) for northern bobwhites on control and feeder areas by month on Packsaddle WMA, Ellis county, Oklahoma, 1991-96.

	Treatment					
	Control		Feeder			
Month	(s)	SE	(s)	SE	Z	P[a]
January	0.76	0.036	0.74	0.038	0.38	0.6480
February	0.78	0.035	0.86	0.033	-1.66	0.0485
March	0.88	0.030	0.91	0.022	-0.81	0.2090
April	0.94	0.021	0.90	0.022	1.32	0.9066
May	0.87	0.028	0.92	0.021	-1.43	0.0764
June	0.91	0.026	0.90	0.024	0.28	0.6103
July	0.89	0.027	0.88	0.026	0.27	0.6064
August	0.92	0.020	0.91	0.023	0.33	0.6293
September	0.96	0.015	0.92	0.022	1.50	0.9332
October	0.91	0.021	0.93	0.020	-0.69	0.2451
November	0.86	0.025	0.90	0.020	-1.25	0.1057
December	0.75	0.035	0.79	0.029	-0.88	0.1894

[a]P-value for 1-tailed Z-test, H_o: Survival rates on the control treatment are greater than or equal to survival rates on the feeder treatment.

Table 2. Estimates of northern bobwhite mean covey size by season, treatment, year, and pooled over treatments and years on Packsaddle WMA, Ellis county, Oklahoma, 1991-96.

Year	Treatment								
	Control			Feeder			Pooled		
Season	n	$\bar{x}$	SE	n	$\bar{x}$	SE	n	$\bar{x}$	SE
1991									
Fall	25	15.5	1.28	22	14.0	1.76	47	14.8	1.06
1992									
Spring	7	10.0	1.31	9	9.8	1.75	16	9.9	1.11
Fall	13	17.8	0.96	16	15.6	0.75	29	16.6	0.62
1993									
Spring	4	10.8	2.25	2	5.5	0.50	6	9.0	1.81
Fall	14	9.9	1.81	16	14.3	0.52	30	12.3	0.96
1994									
Spring	4	13.0	1.22	6	5.3	1.89	10	8.4	1.72
Fall	13	14.9	0.79	10	12.3	2.00	23	13.8	0.99
1995									
Spring	2	4.0	1.00	3	4.3	2.40	5	4.2	1.36
Fall	20	12.8	1.36	19	12.7	1.31	39	12.7	0.93
1996									
Spring	3	4.7	1.86	16	5.8	1.03	19	5.6	0.90
Fall	10	12.1	1.45	15	15.9	1.44	25	14.4	1.09
1991-96									
Spring	20	9.4	0.97	36	6.6	0.77	56	7.6	0.63
Fall	95	14.0	0.60	98	14.2	0.58	198	14.1	0.42