Recovery Rates of Banded vs. Radiomarked Northern Bobwhites in Western Oklahoma

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Abstract: We estimated interval (Dec–Feb) recovery and survival rates of marked northern bobwhites (*Colinus virginianus*) to determine effects of radiomarking and supplemental feeding on the Packsaddle Wildlife Management Area (WMA) in western Oklahoma from 1991 to 1996. We also estimated unretrieved harvest (crippling loss) reported by hunters and compared it to unretrieved harvest of radiomarked bobwhites to determined accuracy of hunter information. We banded 308 and radiomarked 296 bobwhites. Interval survival and recovery rates were estimated using the computer program MARK. Recovery rates of banded bobwhites (0.39) differed ($\chi^2 = 5.03$, $P = 0.03$) from radiomarked bobwhites (0.30). Estimated interval survival rates differed ($\chi^2 = 42.1$, $P <$ 0.01) between banded (0.19) and radiomarked bobwhites (0.56). In our study, radiomarking bobwhites had an apparent positive influence on survival. Radiotelemetry study results should be interpreted cautiously, as estimates of mortality and survival may be biased. The interval recovery and survival rates did not differ ($\chi^2 = 0.09$, $P =$ 0.77; $\chi^2 = 0.03$, $P = 0.87$) between supplementally-fed and control areas, respectively. Supplemental feed had little or no effect on bobwhite overwinter survival or harvest during controlled hunts. Mean unretrieved harvest estimated by hunters (13.7%) and from the radiomarked sample (11.8%) did not differ ($Z = 0.69$, $P = 0.25$). Hunters appeared to provide reliable estimates of unretrieved harvest.

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Northern bobwhite research has been primarily descriptive in the past, but recent improvements in radiotelemetry have enabled researchers to better estimate population parameters and model bobwhite populations (Curtis et al. 1988, Burger et al. 1995*a*, 1995*b*). Banding and/or radiomarking bobwhites have become common tools for determination of habitat use, survival rates, cause-specific mortality, movement patterns, and reproductive activity. Most radiotelemetry studies assume survival, behavior, and other responses of radiomarked animals are not different from untagged animals (Burger et al. 1991, Osborne et al. 1997). Comparative survival and recovery rates from hunting between banded and radiomarked bobwhites could determine the effects of radiomarking bobwhites. Mueller et al. (1989) assumed no differential mortality between radiomarked and unmarked bobwhites provided an acclimation period was used to allow for adjustment to the radiocollar. The suggested acclimation period varies from 1 (Robinette and Doerr 1993, Burger et al. 1995*b*) to 2 weeks (DeVos and Mueller 1993). If estimates of hunting mortality were biased by radiomarking bobwhites, other cause-specific mortality estimates could be biased.

Supplemental feeding is commonly used to augment bobwhite populations (Frye 1954, Guthery 1986:48, Peoples 1992). However, few studies have examined the effects of supplemental feeding on wild bobwhite populations (Frye 1954, Peoples 1992). It is often assumed that supplemental feeding increases overwinter survival (Guthery 1986:48) and concentrates birds for hunting purposes (Lehmann 1984:217). Comparisons of survival and recovery rates on a supplementary-fed and control areas would be useful in determining benefits of supplementally feeding bobwhites.

Data collected on bobwhite harvest is often provided by hunters (Bennitt 1945, Parmalee 1953, Doster et al. 1982, Hurst and Warren 1982, Roseberry and Klimstra 1992, 1993). However, reliability of these data is unknown. Hunter reports or observation of hunter activity commonly are used to estimate unretrieved harvest (crippling loss; Bennitt 1945, Parmalee 1953, Rosene 1969, Doster et al. 1982, Shupe et al. 1990). We used radiotelemetry to investigate the effects of different marking techniques on estimated bobwhite population parameters. Our objectives were to determine if there were differences in survival and recovery rates of banded vs. radiomarked bobwhites, to determine if there were differences in survival and recovery rates between supplementally-fed and control populations of bobwhites, and to compare reported unretrieved harvest by hunters with unretrieved harvest estimated from a radiomarked bobwhite population.

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Methods

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) provided details on the Packsaddle WMA study area. Soils in the area included 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 of approximately 300 ha. One area was supplemented with milo *ad libitum* in gravity-flow feeders, distributed at about 1 feeder/8 ha. The second area served as a control, and was separated from the feeder area by a 1.2-km wide buffer zone.

Bobwhites were captured in modified Stoddard funnel traps (Wilbur 1967) baited with milo or wheat. Traps were placed at a density of 1/32 ha, but were not evenly distributed. Bobwhites trapped on the control area were assigned to the control treatment and bobwhites caught on the feeder area were assigned to the feeder treatment. Sex and age (adult or young of year) of captured bobwhites were determined by plumage characteristics and molt patterns (Rosene 1969:44–54). Radio transmitters and marking methods were described by DeMaso et al. (1997).

Trapping occurred throughout the year for other study objectives; however, we report data only from bobwhites captured each November from 1991 to 1996. Bobwhites were placed into 2 categories: banded, and radiomarked and banded. Numbers of marked birds in each category were not equal (Table 1). All marked birds were assumed to enter the December population. Recaptures and recoveries were recorded from December through February.

Interval survival and recovery estimates were calculated using program MARK, which uses a modified Jolly-Seber model (Burnham 1993). Survival and recovery rates were calculated for each year of harvest for banded and radiomarked bobwhites. Bobwhites harvested in November ($N < 10$) were combined with the December harvest. Interval survival and recovery rates pooled over marking type were

Table 1. Number of banded and radiomarked northern bobwhites marked (*N*) in November, and number harvested (*N*H) from December to February on Packsaddle WMA, Ellis County, Oklahoma, 1991–92 to 1995–96.

	Marking Method			
	Banded		Radiomarked	
Year	*N*	*N*H	*N*	*N*H
1991–92	51	24	34	7
1992–93	153	66	94	55
1993–94	23	9	59	16
1994–95	55	13	62	9
1995–96	26	15	47	14
Total	308	127	296	101

calculated for the fed and control areas. Assumptions associated with the model were provided by Nichols et al. (1982), Pollock and Raveling (1982), Brownie et al. (1985), and Pollock et al. (1995). We believed that most of the model assumptions to estimate survival and recovery rates were met. However, the assumption of no band or radio loss may not be valid because bobwhites can lose radios (Burger et al. 1995*a*). Differences between mark categories and feeding treatments were compared with a log-likelihood ratio (χ^2; Burnham et al. 1995) and considered significant if $P < 0.05$.

Controlled hunts occurred Tuesday and Saturday of each week from about 1 December to 15 February. An average of 21 hunts were held per year and each hunt averaged 15 hunters/day (range: 3–35). Hunters were required to check all harvested bobwhites at a check station before leaving the WMA. Therefore, the reporting rate was assumed to be 100% of the bobwhites retrieved. Each hunter was asked how many birds were retrieved and how many were not retrieved.

Percent unretrieved harvest from hunter reports was estimated as [number of bobwhites reported unretrieved/total harvested (bobwhites harvested + bobwhites unretrieved)]. We compared hunter-reported rates with unretrieved harvest of radiomarked bobwhites. Unretrieved harvest of radiomarked birds was estimated as number of radiomarked bobwhites left in the field that were unretrieved when located by radio telemetry/total number of radiomarked bobwhites retrieved by hunters. Radiomarked birds were located the morning following a hunt to determine the number of unretrieved radioed birds remaining in the field and to minimize confounding the cause of mortality. We used a Z test to determine differences between the proportions of unretrieved harvest by hunters and that of the radiomarked sample. Differences were considered significant if $P < 0.05$.

Results

We banded and radiomarked 308 and 296 bobwhites, respectively, over the course of the study. Totals of 127 banded and 101 radiomarked bobwhites were recovered by hunting (Table 1). Interval (Dec–Feb) survival estimates were lower ($P < 0.05$) for the banded group than for the radiomarked group (Table 2) for all years and years pooled except the 1993–94 and 1994–95 hunting seasons. Recovery estimates during December through February were higher ($P < 0.05$) for banded than for radiomarked birds in the 1995–96 hunting season and all years pooled (Table 2).

When the banded and radiomarked categories were pooled, interval survival rates differed between areas in the 1992–93 season (Table 3). However, areas did not differ when pooled over years (Table 3). Recovery rates between areas varied among years, but did not differ among years and years pooled, except in the 1991–92 hunting season (Table 3).

Mean unretrieved harvest rate for radiomarked bobwhites was 11.9% and did not differ ($Z = 0.69$, $P = 0.25$) from that reported by hunters (13.7%). The rate was similar for each year except the 1995–96 hunting season, when no unretrieved harvest was observed by radiotelemetry (Table 4).

Table 2. Estimated interval (Dec–Feb) survival *(S)*, recovery rates *(R)*, and 95% confidence intervals (CI) of banded and radiomarked northern bobwhites, by year and pooled over years, on Packsaddle WMA, Ellis County, Oklahoma, 1991–92 to 1995–96.

	Marking Method											
	Banded				Radiomarked				Survival		Recovery	
Year	*S*	95% CI	*R*	95% CI	*S*	95% CI	*R*	95% CI	χ^2	*P*	χ^2	*P*
1991–92	0.23	0.10–0.42	0.48	0.34–0.61	0.63	0.19–0.92	0.28	0.09–0.60	4.27	0.04	0.50	0.48
1992–93	0.16	0.10–0.25	0.43	0.36–0.51	0.64	0.43–0.81	0.37	0.22–0.55	32.99	<0.01	0.27	0.61
1993–94	0.32	0.11–0.64	0.31	0.16–0.53	0.56	0.29–0.80	0.34	0.19–0.53	1.53	0.22	0.04	0.85
1994–95	0.35	0.15–0.61	0.25	0.15–0.38	0.60	0.21–0.90	0.19	0.08–0.40	1.89	0.17	0.23	0.63
1995–96	0.13	0.04–0.34	0.58	0.39–0.75	0.39	0.23–0.58	0.32	0.20–0.48	4.95	0.03	4.17	0.04
Pooled	0.19	0.14–0.27	0.39	0.34–0.45	0.56	0.44–0.67	0.30	0.23–0.37	42.06	<0.01	5.03	0.03

Table 3. Estimated interval (Dec–Feb) survival *(S)*, recovery rates *(R)*, and 95% confidence intervals (CI) of northern bobwhites on control and feeder areas, by year and pooled over years, on Packsaddle WMA, Ellis County, Oklahoma, 1991–92 to 1995–96.

	Area											
	Control				Feeder				Survival		Recovery	
Year	*S*	95% CI	*R*	95% CI	*S*	95% CI	*R*	95% CI	χ^2	*P*	χ^2	*P*
1991–92	0.43	0.24–0.64	0.50	0.34–0.66	0.25	0.09–0.54	0.18	0.09–0.33	1.28	0.26	9.51	0.01
1992–93	0.26	0.17–0.38	0.35	0.27–0.43	0.45	0.32–0.59	0.39	0.30–0.50	5.56	0.02	0.48	0.49
1993–94	0.41	0.15–0.74	0.37	0.21–0.58	0.37	0.13–0.68	0.25	0.14–0.40	0.04	0.84	1.24	0.26
1994–95	0.56	0.26–0.83	0.17	0.08–0.31	0.40	0.18–0.67	0.32	0.19–0.50	0.84	0.36	1.46	0.23
1995–96	0.39	0.20–0.63	0.34	0.21–0.51	0.21	0.09–0.43	0.52	0.35–0.69	1.76	0.18	2.15	0.14
Pooled	0.36	0.28–0.44	0.33	0.27–0.38	0.37	0.28–0.46	0.34	0.28–0.40	0.03	0.87	0.09	0.77

Table 4. Reported harvest and unretrieved harvest of bobwhites by hunters and estimated from a radiomarked bobwhite population, by year and pooled over years on Packsaddle WMA, Ellis County, Oklahoma, 1991–92 to 1995–96.

	Hunter harvest report					Radiomarked sample				
	Retrieved		Unretrieved		Total harvested	Retrieved		Unretrieved		Total harvested
Year	*N*	%	*N*	%	*N*	*N*	%	*N*	%	*N*
1991–92	1,260	86	201	14	1,461	28	85	5	15	33
1992–93	1,150	88	153	12	1,303	33	85	6	15	39
1993–94	778	86	129	14	907	27	87	4	13	31
1994–95	1,249	86	206	14	1,455	26	84	5	16	31
1995–96	671	85	116	15	787	36	100	0	0	36
Pooled	5,108	86	805	14	5,913	150	88	20	12	170

Discussion

Estimation of population parameters using radiotelemetry assumes that behavior and other attributes are not affected by the radio transmitter (Burger et al. 1991). This assumption needs to be more rigorously investigated. Estimated interval survival for radiomarked bobwhites, using a band recovery model, was more than twice that of banded bobwhites. We also observed that the recovery rate for radiomarked birds was 30% less than for banded bobwhites. Osborne et al. (1997) observed radiomarked captive bobwhites had lower body weights and total body lipids than a control set of bobwhites. Lipid mass is a high source of energy in birds (Griminger 1986). Possibly, radiomarked bobwhites with lower lipid mass (less energy) would have a tendency to stay on the ground longer when encountered, either by running or "holding tight," than banded bobwhites. This may influence their vulnerability to harvest and other forms of predation, which could lead to biased estimates of recovery and survival rates. We may have experienced some bias in the reporting rate of radiomarked birds (i.e., hunters keeping radios and not reporting them). Also, radiomarked birds may have been habituated to people because of constant radiotracking and human contact and therefore did not flush as readily. Nevertheless, we believe that results of studies of bobwhite population parameters estimated using radiotelemetry (e.g., Curtis et al. 1988, White et al. 1990, Burger et al. 1995*a*, 1995*b*) should be interpreted cautiously until further research investigates the effects of radio transmitters on northern bobwhites.

We were unable to find other studies that researched the effects of supplemental feeding on bobwhite overwinter survival and recovery estimates. Our data suggest that supplemental feed did not affect bobwhite overwinter survival or recovery rate estimates during controlled hunts (when using a band recovery model). However, we did observe variation among years. Results may vary depending on weather conditions and the portion of the bobwhite's range where research is conducted. We believe that in certain times (e.g., adverse weather conditions), supplemental feed may have some benefit, but concentration of predators and other factors may negate these benefits.

Unretrieved harvest in other studies has ranged from 7.4% to 24.1% (Bennitt 1945, Parmalee 1953, Rosene 1969, Kellogg and Doster 1972, Doster et al. 1982). Our estimates of unretrieved harvest fall within the range of these studies (Table 4). Most of these studies used hunter reports or researchers collected data when hunting. We could not find any studies in the literature that compared unretrieved harvest reported by hunters and unretrieved harvest from a radiomarked sample. We believe that hunters provide a valuable source of information about bobwhite harvest and hunting effort.

We used radiotelemetry to investigate the effects of different marking techniques on estimated bobwhite population parameters. Interval recovery and survival rates differed between banded and radiomarked bobwhites, but not between supplementally-fed and control areas. Estimates of unretrieved harvest reported by hunters and estimated from a radiomarked bobwhite population were similar. We feel that additional research is needed to adequately address biases associated with marking bobwhites for purposes of estimating population parameters. Research conducted using radiotelemetry should be interpreted with caution. Management and research communities should be aware that marking biases may exist and results from these studies should be kept in context until improved methods for estimating population parameters are developed.

Literature Cited

Bennitt, R. 1945. Some social factors influencing quail hunting in Missouri, 1938–1944. J. Wildl. Manage. 9:195–202.

Brownie, C. D., D. R. Anderson, K. P. Burnham, and D. S. Robson. 1985. Statistical inference from band recovery data: a handbook, 2nd ed. U.S. Dep. Int., Fish and Wildl. Serv. Res. Publ. 156.

Burger, L. W., Jr., M. R. Ryan, D. P. Jones and A. P. Wywialowski. 1991. Radio transmitters bias estimation of movements and survival. J. Wildl. Manage. 55:693–697.

———, T. V. Dailey, E. W. Kurzejeski, and M. R. Ryan. 1995*a*. Survival and cause-specific mortality of northern bobwhite in Missouri. J. Wildl. Manage. 59:401–410.

———, M. R. Ryan, T. V. Dailey, and E. W. Kurzejeski. 1995*b*. Reproductive strategies, success, and mating systems of northern bobwhites in Missouri. J. Wildl. Manage. 59:417–426.

Burnham, K. P. 1993. A theory for combined analysis of ring recovery and recapture data. Pages 199–213 *in* J. D. Lebreton and P. M. North, eds. Marked individuals in the study of bird population. Birkhauser Verlag, Basel, Switzerland.

———, D. R. Anderson, and G. C. White. 1995. Selection among open population capture-recapture models when capture probabilities are heterogeneous. J. Appl. Stat. 22:611–624.

Cole, E. L., A. J. Conradi, and C. E. Rhoades. 1966. Soil survey of Ellis county, Oklahoma. U.S. Dep. Agric., Soil Conserv. Serv., Washington, D.C. 136pp.

Curtis, P. D., B. S. Mueller, P. D. Doerr, and C. F. Robinette. 1988. Seasonal survival of radiomarked northern bobwhite quail from hunted and non-hunted populations. Biotelemetry 10:263–275.

DeMaso, S. J., A. D. Peoples, S. A. Cox, and E. S. Parry. 1997. Survival of northern bobwhite chicks in western Oklahoma. J. Wildl. Manage. 61:846–853.
DeVos, T. and B. S. Mueller. 1993. Reproductive ecology of northern bobwhite in north Florida. Pages 83–90 *in* K. E. Church and T. V. Dailey, eds. Quail III: Natl. Quail Symp. Kan. Dep. Wildl. and Parks, Pratt.
Doster, G. L., F. E. Kellogg, W. R. Davidson, and W. M. Martin. 1982. Hunter success and crippling losses for bobwhite quail. Pages 45–47 *in* F. Schitosky, Jr., E. C. Schitosky, and L. G. Talent, eds. Proc. Second Natl. Bobwhite Quail Symp., Okla. State Univ., Stillwater.
Frye, O. E., Jr. 1954. Studies of automatic quail feeders in Florida. Trans. North Am. Wildl. Conf. 19:298–319.
Griminger, P. 1986. Lipid metabolism. Pages 345–358 *in* P. D. Sturkie, ed. Avian physiology, Springer-Verlag, New York.
Guthery, F. S. 1986. Beef, brush, and bobwhites: quail management in cattle country. Caesar Kleberg Wildl. Res. Inst. Press, Kingsville, Texas. 182pp.
Hurst, G. A. and R. C. Warren. 1982. Harvest rates and efforts of avid quail hunters in east central Mississippi. Pages 48–50 *in* F. Schitosky, Jr., E. C. Schitosky, and L. G. Talent, eds. Proc. Second Natl. Bobwhite Quail Symp., Okla. State Univ., Stillwater.
Kellogg, F. E. and G. L. Doster. 1972. Bobwhite quail: Total hunter kill compared to number retrieved. Proc. Annu. Conf. Southeast. Assoc. Game and Fish Comm. 25:147–149.
Lehmann, V. W. 1984. Bobwhites in the Rio Grande plain of Texas. Texas A&M Univ. Press, College Station. 371pp.
Mueller, B. S., J. B. Atkinson, Jr., and T. DeVos. 1989. Mortality of radio-tagged and unmarked northern bobwhites. Biotelemetry 10:139–144.
Nichols, J. D., S. L. Stokes, J. E. Hines, and M. J. Conroy. 1982. Additional comments on the assumptions of homogeneous survival rates in modern bird banding estimation models. J. Wildl. Manage. 46:953–962.
Osborne, D. A., B. J. Frawley, and H. P. Weeks, Jr. 1997. Effects of radio tags on captive northern bobwhite (*Colinus virginianus*) body composition and survival. Am. Midl. Nat. 137:213–224.
Parmalee, P. W. 1953. Hunting pressure and its effect on bobwhite quail populations in east-central Texas. J. Wildl. Manage. 17:341–345.
Peoples, A. D. 1992. Production, utilization, and nutritional value of supplemental feed to northern bobwhites in western Oklahoma. M.S. Thesis, Okla. State Univ., Stillwater. 121pp.
Pollock, K. H. and D. G. Raveling. 1982. Assumptions of modern band-recovery models with emphasis on heterogeneous survival rates. J. Wildl. Manage. 46:88–98.
———, M. J. Conroy, and W. S. Hearn. 1995. Separation of hunting and natural mortality using ring-return models: an overview. J. Appl. Stat. 22:557–566.
Robinette, C. F. and P. D. Doerr. 1993. Survival of northern bobwhite on hunted and non-hunted study areas in the North Carolina sandhills. Pages 74–78 *in* K. E. Church and T. V. Dailey, eds. Quail III: Natl. Quail Symp., Kan. Dep. Wildl. and Parks, Pratt.
Roseberry, J. L. and W. D. Klimstra. 1992. Further evidence of differential harvest rates among bobwhite sex-age groups. Wildl. Soc. Bull. 20:91–94.
——— and ———. 1993. Attitudes of a select group of Illinois quail hunters. Pages 34–42 *in* K. E. Church and T. V. Dailey, eds. Quail III: Natl. Quail Symp., Kan. Dep. Wildl. and Parks, Pratt.
Rosene, W. 1969. The bobwhite quail: its life and management. Rutgers Univ. Press, New Brunswick, N.J. 418pp.

Shupe, T. E., F. S. Guthery, and R. L. Bingham. 1990. Vulnerability of bobwhite sex and age classes to harvest. Wildl. Soc. Bull. 18:24–26.

White, D. H., J. T. Seginak, and R. C. Simpson. 1990. Survival of northern bobwhite in Georgia: cropland use and pesticides. Bull. Environ. Contam. and Toxicol. 44:73–80.

Wilbur, S. R. 1967. Live-trapping North American upland game birds. U.S. Dep. Int., Fish and Wildl. Serv. Spec. Sci. Rep. 106. 37pp.