Survival of Game Farm, F1-Wild Progeny, and Wild-relocated Northern Bobwhites Using Two Release Methods

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Abstract: We estimated survival rates and cause-specific mortality of radio-marked game farm (N=120), F1-wild progeny (N=120), and wild-relocated northern bobwhites *(Colinus virginianus)* (N=80) released on the Amelia Wildlife Management Area (WMA) during October 1998 and March 1999 using the Anchor Covey Release System™ (ACRS) and a habitat release system. Mortality of game farm and F1 bobwhites was high immediately following both releases. During fall, game farm bobwhites survived an average of 1.6 ± 0.2 days and F1-wild progeny survived 3.3 ± 0.8 days. Post-release survival of game farm and F1 bobwhites released during spring averaged 3.8 ± 0.4 and 6.1 ± 2.4 days, respectively. Survival of pen-raised and F1 bobwhites did not differ (P>0.05) between seasons or by release method. Wild-relocated bobwhites survived longer (P≤0.05) than game farm and F1 birds during both seasons. Predation was the primary cause of morality for released bobwhites. Mammalian predators killed a greater (P≤0.05) proportion of game farm (55.8%) and F1 birds (48.3%) than wild-relocated (32.5%) birds. The proportion of avian predation was greater for bobwhites released using the ACRS than the habitat release system (P=0.07) and also was greater (P≤0.05) during spring than fall. We found no evidence that the ACRS enhanced survival of game farm or F1 bobwhites. Although game farm bobwhites reportedly survive longer following release in some areas, our data suggest that the release of game farm and F1-wild birds to restock depleted northern bobwhite range is unjustified in situations similar to those we studied.

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Northern bobwhite populations have declined substantially in Virginia and throughout the Southeast during recent decades (Brennan 1991, Fies et al. 1992, Church et al. 1993). As opportunities to hunt wild bobwhites have diminished, interest in release of pen-raised birds to supplement native populations has increased. Although most biologists recognize the value of releasing pen-raised birds for dog-training or field trial purposes, stocking game farm bobwhites to establish wild populations has long been considered an ineffective practice. Numerous studies have documented poor survival of liberated pen-raised bobwhites (Gerstell 1938, Baumgartner 1944, Phelps 1948, Beuchner 1950, Mueller 1984). Some researchers also have expressed concern regarding possible negative effects of releasing pen-raised quail on wild bobwhite populations (Landers et al. 1991). Disease introduction, dilution of the native gene pool, and increased predation risk are some of the potential impacts commonly mentioned (Pough 1948). However, little data exists to assess the actual extent of these problems (DeVos and Speake 1995).

Despite these concerns, releasing pen-raised bobwhites continues to be a common practice among sportsmen and landowners. Large numbers of bobwhites are annually released on managed shooting preserves, where harvest pressure often exceeds availability of wild birds. Although most of these releases are "put and take" operations with birds released immediately prior to the hunt, a growing number of preserves are conducting pre-season releases where bobwhites are released 1 to 2 months prior to the hunting season. Reported harvest rates for banded bobwhites released on managed areas during the pre-season usually range from 10% to 35% (DeVos and Speake 1995). Manufacturers of commercially produced release systems, such as the Anchor Covey Release System™ (currently known as Covey Base Camp™), claim that survival of these pen-raised bobwhites can be enhanced by using their product (Thomas 1997). However, there are no published studies to substantiate these claims.

Biologists generally assume that pen-raised bobwhites survive poorly because they lack behavioral characteristics necessary to escape from predators. Improved rearing methods that minimize human contact and infusion of wild genetic material into pen-raised stock have been suggested as ways to improve quality of released bobwhites (Kozicky 1993). Backs (1982) reported that first generation (F1) bobwhites bred from wild stock were more secretive, wary, and sensitive to observer approach. The purpose of our study was to determine if survival rates of pen-raised bobwhites could be increased by using wild genetic stock in conjunction with the most current release methodologies. Specifically, we studied survival rates of game farm, F1-wild progeny, and wild-relocated bobwhites using the Anchor Covey Release System™ and a habitat release system.

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Methods

Study Area

Experimental releases were made on the Amelia WMA, located in southcentral Virginia, approximately 40 km southwest of Richmond, in Amelia County. The area is 897 ha of primarily upland habitat, a large portion of which is managed specifically for northern bobwhites, eastern cottontails *(Sylvilagus floridanus),* and mourning dove *(Zenaida macroura).* Habitat management activities on the area include fescue *(Festuca arundinacea)* eradication, warm season grasses plantings, prescribed burning, hedgerow development, supplemental food plot management, and timber harvest. Despite management efforts, wild bobwhite populations on the area have traditionally been low, presumably due to overharvest and excessive disturbance (Fies and Needham 1999). In 1998, a permit hunting system was instituted to restrict hunter harvest. The Amelia WMA was selected for this study because habitat quality appeared to be high and wild bobwhite populations were low, a combination of conditions for which the release of pen-raised bobwhites is frequently recommended.

Bobwhite Propagation and Trapping

We captured 56 wild bobwhites (40 males, 16 females) from 17 March to 13 April 1998 to use as parental stock for F1 progeny. Bobwhites were captured in 61 × 61 × 20 cm funnel cage traps (Stoddard 1931:442–445) baited with cracked corn. We trapped and removed wild bobwhites from Princess Anne WMA (city of Virginia Beach), Hog Island WMA (Surry County), and Radford Army Ammunition Plant (Pulaski County) where public quail hunting was not permitted. Post-capture mortality and lack of available hens resulted in only 14 pairs being available for breeding. All bobwhites were transferred to a private game bird propagation facility (Monterey Farms, Greenwood, Va.).

Each pair of bobwhites was housed in an individual section (25 × 61 × 25 cm) of larger breeding cages. These cages were located in a separate room of the facility to minimize disturbance. Breeding quail were visited only once daily to provide food and water. Cut cedar trees were placed in stands located near the front of the cages to provide concealment and minimize stress.

From these 14 pairs, 493 eggs were produced ($\bar{x}$=35.2 eggs/hen, range: 8–67) and placed into large commercial incubators. Approximately 350 F1 progeny were hatched for use in this study. Chicks were transferred to brooder cages immediately after hatching and remained there for 7–8 weeks. Young bobwhites were then moved into large outdoor pens (1.4 × 2.4 × 9.8 m) where they were housed until release. Clumps of vegetation containing wild food plants (i.e., ragweed *[Ambrosia artemisifolia],* foxtail grass [*Setaria* spp]) were placed in cages to familiarize F1 progeny with naturally occurring food sources. Game farm bobwhites, typical of those sold by game bird breeders, were simultaneously hatched and reared at the same facility using traditional rearing methods. We minimized human contact during all stages of chick development for both the F1 progeny and game farm bobwhites.

We captured wild bobwhites for relocation on the Eastern Shore National Wildlife

Refuge and Kiptopeke State Park, located on the Delmarva Peninsula in Northampton County, Virginia. Wild bobwhites were trapped between 28 September and 23 October 1998 for the fall release, and again between 16 February and 19 March 1999 for the spring release. We trapped 104 wild bobwhites (45 males, 59 females) during both periods. Captured bobwhites were held in a small pen located on the Eastern Shore Refuge until they could be transported (usually within 48 hours) to a larger indoor holding pen (2.4 × 7.9 × 1.8 cm) at the same private game bird facility where the captive birds were raised. The indoor pen was lined with soft netting to minimize injury and cut cedar trees were placed inside the pen to provide escape cover. Water and food (commercial feed, wheat, and cracked corn) were supplied next to the escape cover. Wild bobwhites were held in the indoor pen until the scheduled release dates for all types of birds.

Bobwhite Release and Monitoring Procedures

We selected 14 release sites in areas having a combination of thick escape cover and open field habitat. Most sites were located at least 0.8 km apart to minimize opportunities for interactions among release groups. A small teepee-shaped frame with a feeder and waterer (Anchor Covey Release System™, Quality Wildl. Serv. Inc., Waynesboro, Ga.), was used at half (N=7) of the release sites. The remaining half were habitat release sites, areas with woody escape cover adjacent to a planted food source (no feeder units). These areas were usually a mixture of blackberry (*Rubus* spp) and honeysuckle *(Lonicera japonica)* next to a planted strip of partridge pea *(Cassia fasciculata)*. The bird type released at each site was randomly assigned during each season, stratified by release method. Game farm bobwhites were released at 6 of 14 sites (N=3 ACRS, N=3 habitat), F1 birds were released at 6 sites (N=3 ACRS, N=3 habitat), and wild-relocated bobwhites were released at 2 sites (N=1 ACRS, N=1 habitat). Wild-relocated birds were released at only 2 sites because fewer birds of this type were available for study.

Mid-sized mammalian predators were trapped on the study area prior to spring release, but not prior to fall release. From 1 to 5 February and 16 to 20 March 1999, 2 experienced trapping parties captured and removed 2 gray foxes *(Urocyon cinereoargenteus)*, 2 red foxes *(Vulpes vulpes)*, 1 bobcat *(Lynx rufus)*, 8 raccoons *(Procyon lotor)*, 3 striped skunks *(Mephitis mephitis)*, and 4 oppossums *(Didelphis virginiana)* from the release areas.

ACRS units were installed several weeks prior to each release. A metal brush frame was placed over a small cleared area (1.2 × 1.2 m) in thick escape habitat with good overhead cover. The feeder and waterer were then filled (whole grain wheat used for food) and a camouflaged Cordura® cover was placed over the frame. Evergreen branches were attached to the cover to further conceal the unit. A call bird (adult male bobwhite) was placed in a small cage located in a tree approximately 6–9 m from the frame and 1.8–2.1 m above the ground. By periodically calling, this bird is supposed to attract released bobwhites back to the feeder and "anchor" the covey to the release site. The site selection and setup procedures we used were identical to those recommended in the manufacturer's guide book and instructional video. In addition, habitat conditions at most sites were inspected by the system designer and deemed to be suitable prior to release (J. Evans, Quality Wildl. Serv., pers. commun.).

We attached necklace-style radio transmitters (Am. Wildl. Enterprises, Monticello, Fla.) to half of the game farm and F1-wild bobwhites and all wild-relocated bobwhites. All birds were leg banded, including those without radios. Transmitters weighed approximately 6 g and contained a 1-hour mortality sensor to facilitate quick recovery of remains. Radios were attached 3 days prior to release to allow birds to become accustomed to wearing the unit. Sex, age, weight, and general condition of all birds were determined when radios were attached. All bobwhites were at least 12 weeks old when released and radio-marked birds weighed at least 150 g.

Bobwhites were released in groups of 20 birds at each of the 14 sites during fall and spring. On the morning of the release (the evening prior for the spring release), we packaged each group of 20 birds into plastic crates (43 ×61× 13 cm) for transport to the study area. Bobwhites were assigned to each group prior to packing to ensure an equal sex and size distribution per release site. Aside from being held together in individual crates for 3–6 hours (fall release) and 16–20 hours (spring release), no attempt was made to isolate and hold groups together for the purpose of developing covey bonds. The fall release was on 25 October 1998 and the spring release occurred on 23 March 1999. Both release dates were warm, sunny days with above average temperatures. All birds were released as early as possible during the day to allow them to acclimate to their new surroundings before dark. All birds were released between 1200 and 1600 hours during fall and prior to 1000 hours during spring.

At ACRS sites, bobwhites were released by placing the crate next to the brush frame with the door facing the unit. At habitat sites, we placed the crate on a small area (1.2 ×1.2 m) of cleared ground in thick escape cover. The top of each crate was covered with evergreen branches and the front door was opened slowly to discourage immediate flushing. We quietly left the area to allow bobwhites to exit the crate without disturbance. During the fall release, a thin block of ice (water frozen and removed from a 0.47 liter freezer bag) was placed in front of the door to prevent birds from exiting the crate until the ice melted and the researchers left the area. This technique was not used during the spring release because we felt that the ice took too long to melt, possibly making birds more vulnerable to predation while trapped in the release cages. Empty crates were removed from each site within 24 hours following release. During the spring release, crates were picked up within several hours to reduce odor at the release site. Call birds were removed from their cages approximately 2 weeks after each release.

We monitored radio-marked bobwhites at least once daily to determine survival. Dead birds were located immediately and all remains were collected for later analyses. The rubber shrink tubing on each transmitter was carefully examined to look for tooth marks and beak impressions. A combination of evidence left at the kill site, condition of the remains, and marks on the transmitter were used to determine the probable cause of death. Intact carcasses were frozen and later necropsied. Whole bobwhites with no apparent wounds or that were emaciated were classified as having died from stress associated with the release.

Survival and cause-specific mortality for radio-tagged bobwhites were calculated as simple percentages. We used Chi-square procedures to test for overall differences between proportions of cause-specific mortalities. A *Z*-test (Brownie et al. 1985) was used to compare proportions of cause-specific mortalities between bird types, release methods, and seasons. Differences in mean number of days survived were evaluated using a factorial analysis of variance (PROC GLM; SAS 1989) with bird type, release method, and season as main effects. A Tukey's Multiple Comparison test was used to compare main effects and combinations of main effects that formed significant ($P \leq 0.05$) interactions.

Results

During each of 2 release periods, 280 bobwhites (N=160 with radios) were released at 14 sites. This total included 120 game farm birds (N=60 radios), 120 F1-wild progeny (N=60 radios), and 40 wild-relocated bobwhites (N=40 radios). The combined total number of birds released during both seasons was 560 (N=320 radios).

Survival

Mortality of game farm bobwhites and F1-wild progeny was high immediately following both releases. During the fall release, all game farm bobwhites with radios died within 9 days after release (Fig. 1). The F1-wild progeny survived only slightly better (all died within 41 days of release). Following the spring release, all game farm bobwhites died within 19 days (Fig. 2). All but 1 F1 bird released during spring survived less than 27 days. Average number of days that game farm and F1 bobwhites survived following the fall release was 1.6 ± 0.2 and 3.3 ± 0.8, respectively. During spring, game farm and F1 birds survived an average of 3.8 ± 0.4 and 6.1 ± 2.4 days after release.

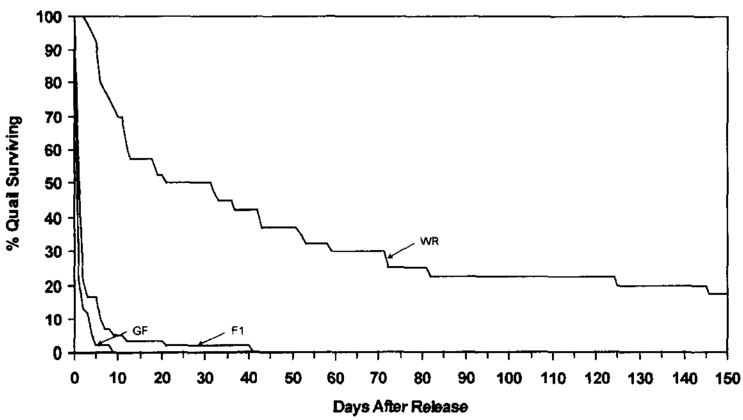

Figure 1. Percentage of radio-tagged game farm (GF), F1-wild progeny (F1), and wild-relocated (WR) northern bobwhites surviving by day after release on Amelia Wildlife Management Area during fall 1998.

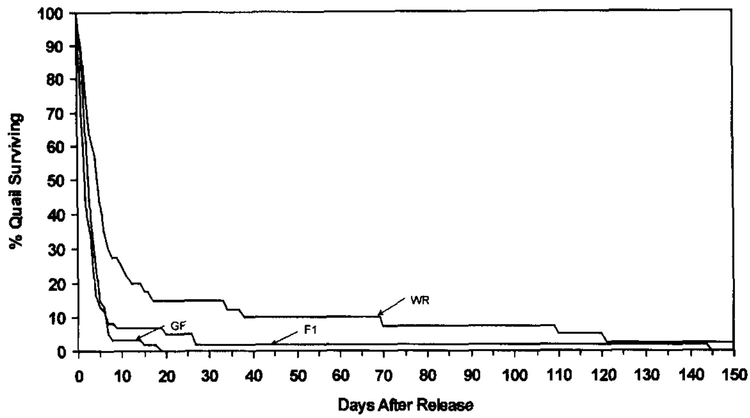

Figure 2. Percentage of radio-tagged game farm (GF), F1-wild progeny (F1), and wild-relocated (WR) northern bobwhites surviving by day after release on Amelia Wildlife Management Area during spring 1999.

Combined season survival of wild-relocated bobwhites was greater ($F_{2,308}$=41.1, P<0.001) than for game farm and F1 birds (Table 1). Survival of game farm and F1 bobwhites was similar between seasons, but wild-relocated birds survived longer ($F_{1,308}$=12.6, P<0.001) following the fall release ($\bar{x}$=58.7±11.6 days) than the spring release ($\bar{x}$=17.9±5.7 days). During fall, 6 of 40 (15.0%) wild-relocated birds lived more than 150 days after release (Fig. 1). Only 1 of 40 (2.5%) wild-relocated birds released during spring survived more than 150 days (Fig. 2). Game farm and F1 bobwhite survival for both seasons was similar between release

Table 1. Mean number of days survived by radio-tagged game farm (GF), F1-wild progeny (F1), and wild relocated (WR) northern bobwhites released using the Anchor Covey Release System™ (ACRS) and a habitat release system during fall (25 Oct) 1998 and spring (23 Mar) 1999 on the Amelia Wildlife Management Area in central Virginia.

		ACRS			Habitat			Pooled		
Season	Bird type	N	$\bar{x}$	SE	N	$\bar{x}$	SE	N	$\bar{x}$	SE
Fall	GF	30	1.0	0.0	30	2.2	0.3	60	1.6	0.2
	F1	30	4.1	1.5	30	2.5	0.5	60	3.3	0.8
	WR	20	75.7	19.4	20	41.6	12.1	40	58.7	11.6
	Pooled	80	20.8	6.0	80	12.1	3.5	160	16.5	3.5
Spring	GF	30	3.7	0.4	30	3.8	0.7	60	3.8	0.4
	F1	30	2.3	0.3	30	9.8	4.8	60	6.1	2.4
	WR	20	24.8	9.7	20	11.0	5.9	40	17.9	5.7
	Pooled	80	8.5	2.6	80	7.8	2.3	160	8.2	1.7
Pooled	GF	60	2.4	0.3	60	3.0	0.4	120	2.7	0.2
	F1	60	3.2	0.7	60	6.1	2.5	120	4.7	1.3
	WR	40	50.3	11.4	40	26.3	7.1	80	38.3	6.8
	Pooled	160	14.6	3.3	160	10.0	2.1	320	12.3	2.0

methods, but wild-relocated birds survived longer ($F_{1,308}$=4.08, P<0.044) at ACRS sites $\bar{x}$=50.3±11.4 days) than at habitat sites ($\bar{x}$=26.3±7.1 days).

Cause-specific Mortality

The proportion of mortality due to specific causes varied (χ^2=17.5, 8 df, P=0.025) among bird types (Table 2). Mammalian predators were responsible for 55.8% of the mortality of game farm birds and 48.3% of F1 bird mortality. The proportion of wild-relocated bobwhites killed by mammalian predators (32.5%) was lower than for game farm and F1 birds (Z=3.00, P=0.001). The primary cause of mortality for wild-relocated birds was avian predation and the proportion of wild-relocated birds killed by avian predators (45.5%) was higher (Z=2.14, P=0.016) than for game farm (32.5%) and F1 (31.7%) birds. Only a small percentage of released birds died from stress (Table 2). Stress accounted for a higher (Z=2.38, P=0.009) proportion of the mortality for F1 birds (7.5%) than for game farm (1.7%) and wild-relocated bobwhites (2.6%).

Mortality from all causes did not appear to vary (χ^2=6.1, 4 df, P=0.195) by release method. However, comparisons of specific causes of mortality revealed that a greater (Z=1.45, P=0.073) proportion of bobwhites released at ACRS sites died from avian predation (Table 3). Mammalian predation was greater (Z=2.42, P=0.008) at habitat sites. Cause-specific mortality also varied (χ^2=12.0, 4 df, P=0.02) by season; avian predation was greater (Z=2.93, P=0.002) during spring than fall (Table 4).

Following the spring release, 2 wild-relocated bobwhites and 1 F1 bird incubated nests. One of the wild-relocated quail nests was unsuccessful after the adult

Table 2. Cause-specific mortality of radio-tagged game farm (GF), F1-wild progeny (F1), and wild-relocated (WR) northern bobwhites released during fall (25 Oct) 1998 and spring (23 Mar) 1999 on the Amelia Wildlife Management Area in central Virginia.

Bird Type	*N*	Cause	*N* deaths	P^a	SE
GF	120	Avian	39	0.325	0.043
		Mammalian	67	0.558	0.045
		Unknown predator	10	0.083	0.025
		Stress	2	0.017	0.012
		Other	2	0.017	0.012
F1	120	Avian	38	0.317	0.043
		Mammalian	58	0.483	0.046
		Unknown predator	13	0.108	0.028
		Stress	9	0.075	0.024
		Other	2	0.017	0.012
WR	77	Avian	35	0.455	0.057
		Mammalian	25	0.325	0.053
		Unknown predator	12	0.156	0.041
		Stress	2	0.026	0.018
		Other	3	0.039	0.022

a. Proportion of deaths attributable to a given cause.

Table 3. Cause-specific mortality of radio-tagged northern bobwhites released during fall (25 Oct) 1998 and spring (23 Mar)1999 on the Amelia Wildlife Management Area in central Virginia using the Anchor Covey Release System™ (ACRS) and a habitat release system.

Method	*N*	Cause	*N* deaths	*P*[a]	SE
ACRS	158	Avian	62	0.392	0.039
		Mammalian	64	0.405	0.039
		Unknown predator	20	0.127	0.027
		Stress	8	0.051	0.017
		Other	4	0.025	0.013
Habitat	159	Avian	50	0.315	0.037
		Mammalian	86	0.541	0.040
		Unknown predator	15	0.094	0.023
		Stress	5	0.031	0.014
		Other	3	0.019	0.011

a. Proportion of deaths attributable to a given cause.

hen was consumed by a black rat snake *(Elaphe obsoleta).* The other 2 nests successfully hatched chicks. The F1 hen hatched 15 chicks, but was consumed by a black rat snake 17 days later. The other wild-relocated hen hatched 11 chicks, but was killed by a mammalian predator 1 day after hatching. High adult mortality immediately after hatching is consistent with results from a 3-year nesting study of wild bobwhites recently completed in Virginia (Fies, unpubl. data) and other studies (Burger et al. 1995).

Discussion

High post-release mortality of pen-raised bobwhites has been reported in many studies (Gerstell 1938, Baumgartner 1944, Phelps 1948, Pierce 1948, Barbour 1950, Buechner 1950). We observed mortality rates of radio-marked game farm and F1

Table 4. Cause-specific mortality of radio-tagged northern bobwhite released during fall (25 Oct) 1998 and spring (23 Mar) 1999 on the Amelia Wildlife Management Area in central Virginia.

Season	*N*	Cause	*N* deaths	*P*[a]	SE
Fall	157	Avian	43	0.274	0.036
		Mammalian	80	0.510	0.040
		Unknown predator	21	0.134	0.027
		Stress	10	0.064	0.020
		Other	3	0.019	0.011
Spring	160	Avian	69	0.431	0.039
		Mammalian	70	0.438	0.040
		Unknown predator	14	0.088	0.022
		Stress	3	0.019	0.011
		Other	4	0.025	0.012

a. Proportion of deaths attributable to a given cause.

bobwhites similar to those reported by other researchers using telemetry techniques. In Louisiana, mortality of radio-tagged game farm bobwhites released on a wildlife management area was 77% after 7 days and 94% after 20 days (M. Olinde, unpubl. rep., La. Dep. Wildl. and Fish., 1996). In Florida, game farm bobwhites with transmitters released during spring survived an average of 10.8 days and the mortality rate was 100% 50 days post-release (Mueller 1985). In Indiana, Backs (1982) reported that radio-marked F1-wild bobwhites released during fall survived longer ($\bar{x}$=41 days) than game farm bobwhites ($\bar{x}$=7 days). In the same study, F1 and game farm bobwhites released during spring survived an average of 41 and 9 days, respectively. In Texas, 50% of game farm and F1-wild bobwhites with radios died within 8 days (Wilson et al. 1996). Radio-tagged F1-wild bobwhites released during fall and spring in Ohio experienced mortality rates of 87.2% and 91.5% during a 10-week post-release monitoring period (Henry and Shipley 1989). In Illinois, there was no apparent difference in survival between game farm and "semi-wild" (offspring of wild × game farm cross) bobwhites released during fall (Roseberry et al. 1987).

Although poor survival of pen-raised bobwhites has been documented in many studies, there also is evidence that released bobwhites survive longer in some areas. Frye (1942) concluded that survival rates of game farm and wild bobwhites were equivalent on a study area in Florida, based on recapture data. However, he suggested that his observations were due to atypical conditions present on the study area, particularly the presence of a large population of wild birds prior to release. He proposed that survival of game farm bobwhites was enhanced by their association with wild birds on the area. Mueller (unpubl. rep., Am. Wildl. Enterprises, Monticello, Fla., 1997) reported that 67% of game farm bobwhites released during fall on a South Carolina plantation survived 90 days post-release. He noted that wild bobwhite populations on the study area were high and that game farm quail readily mixed with wild birds, In fact, no "pure" wild coveys were captured the following March. In Illinois, 51% of pen-raised bobwhites (both game farm and "semi-wild") released during fall survived more than 40 days post-release, presumably influenced by their contact with wild bobwhites on the study area (Roseberry et al. 1987). One-month post-release survival of game farm quail in Alabama was over 60% on study areas where pen-raised and wild birds integrated almost completely (DeVos and Speake 1995).

Mortality of wild-relocated bobwhites in our study was greater than we expected. Roseberry et al. (1987) estimated autumn–spring survival of wild transplants to be 30%–35%, compared to only 15% in our study. In Florida, survival of wild bobwhites relocated during spring was 67% from March to October (DeVos and Mueller 1989). Most likely, wild-relocated bobwhites in our study were stressed from being held in the holding facility, sometimes for several weeks or longer prior to the scheduled release date. Optimally, wild-relocated birds should be transported and released within 24 hours of their capture. The design of this study, however, necessitated that release methods be consistent among bird types and that all bobwhites be released on the same dates. In a similar project, Henry and Shipley (1989) found that 10-week survival of wild-relocated quail held shorter periods of time was 37%, compared to 17% for wild birds held longer periods.

We found no evidence that the ACRS enhanced survival of game farm or F1 bobwhites released on our study area. Sisson (unpubl. rep., Albany Area Quail Mgt. Proj., Auburn, Ala., 2000) also found no significant difference between survival rates of pen-raised bobwhites released using the ACRS and a "dump release" technique on several quail plantations in Georgia. Currently, we know of no published study that demonstrates bobwhites released with the ACRS survive longer than birds released into suitable natural habitat. The ACRS is extremely similar to the Smith-O'Neal system developed in 1969 and described by Kozicky (1987:69). In Indiana, Savery (1972) reported that use of the Smith-O'Neal system did not increase long-term survival rates of released bobwhites.

We cannot explain why wild-relocated bobwhites released at ACRS sites survived longer than those released at habitat sites. We never observed wild-relocated bobwhites in close proximity to ACRS feeder units. We also found no evidence (droppings, feathers, reduced amounts of grain in feeding tubes) that wild-relocated bobwhites utilized the feeders. Habitat quality was presumed to be equal at both types of release sites. We do not believe that ACRS units provided wild-relocated bobwhites with a survival advantage.

Game farm and F1 bobwhites in our study were more susceptible to mammalian predation than wild-relocated birds. Other researchers also have reported a greater incidence of mammalian predation for pen-raised quail than for wild bobwhites (Mueller 1985, DeVos and Speake 1995, Wilson et al. 1996). This observation is most likely due to apparent differences in behavior among bird types. When initially released, wild bobwhites quickly flew from their cages and were never seen near the release site again. In contrast, game farm and F1 birds were slow to leave the release cages, reluctant to fly, easily approached by researchers, and frequently observed within 25 m of the release site. Their lack of wariness and reluctance to fly rendered them particularly susceptible to attack from ground predators.

Avian predation was greater for bobwhites released at the ACRS sites, perhaps because call birds were used. Call birds may have been particularly visible to avian predators and could have attracted raptors to the release site. Sisson (unpubl. rep., Albany Quail Mgt. Proj., Auburn, Ala., 2000) observed a significantly lower survival rate for pen-raised bobwhites released at sites where call birds were used. We also found a greater proportion of avian predation among quail released during spring than fall. Although predator populations were never censused on the study area, we presume that the number of avian predators was higher and the number of mammalian predators lower during spring than fall.

In our study, we attributed stress (primarily from starvation or dehydration) to be responsible for only a small proportion of the total mortality of released birds. However, predators killed a large number of game farm and F1 quail within the first 48 hours post-release and likely influenced the opportunity for them to die from stress-related conditions. Nevertheless, we did not observe game farm and F1 bobwhites to be visibly stressed following release. Most game farm and F1 birds began feeding immediately after release and intact crops recovered from game farm and F1 carcasses usually contained a variety of natural and provided foods. The observation that more F1 birds died from stress than game farm and wild-relocated bobwhites is difficult to explain. Prior to release, F1 birds were noticeably more nervous when we approached the holding pens. As a result, F1 birds may have been more reluctant to move around and perhaps fed less frequently. In Texas, Wilson et al. (1996) also reported that a higher percentage of F1 bobwhites died from starvation than game farm and wild bobwhites. Although wild-relocated bobwhites in our study were obviously more wary than F1 birds, wild bobwhites appeared to travel greater distances and likely had little difficulty locating and utilizing a variety of natural foods.

Mortality rates of released birds may also have been influenced by use of radio transmitters. Although most studies assume that transmitters have little or no effect on survival rates (Osborne et al. 1997), this assumption has not been adequately investigated. Henry and Shipley (1989) reported that bobwhites released without transmitters survived 32% longer than radio-marked quail. In contrast, Parry et al. (1997) found that radio-marked bobwhites survived longer than birds without radios. Mueller et al. (1989) found no difference in survival rates between radio-tagged and unmarked bobwhites.

Although we did not attempt to estimate mortality rates of bobwhites released without transmitters, we observed no apparent behavioral differences between radio-marked and non-radioed birds immediately following release. Remains of non-radioed bobwhites were frequently found near release sites, suggesting that these birds were similarly susceptible to predation. None of the uninstrumented bobwhites released during October 1998 ($N=120$) were harvested by hunters during the 1998–1999 hunting season, and none of the non-radioed birds released during March 1999 ($N=120$) were killed by hunters during the 1999–2000 season.

During our period of study, banded game farm quail were independently released by participants of licensed field trial events on a designated portion (approx. 80 ha) of the WMA. None of our release sites were located on or adjacent to this field trial course. Interestingly, 11 of 604 (1.8%) bobwhites released during field trial events between 12 September and 17 October 1998 were harvested by hunters during the 1998–99 season (Fies and Needham 1999). The following season (1999–2000), 7 of 530 (1.3%) field trial birds released between 11 September and 15 October 1999 were killed by hunters (Fies, unpubl. data). It is possible that game farm bobwhites released individually survived better than game farm or F1 quail released in groups using the ACRS or habitat release systems.

Survival of pen-raised bobwhites following release is generally considered to be influenced by bird quality, habitat conditions, predator numbers, and release method. Game farm and F1 birds used in our study were raised with exceptional care, minimal human contact, and were physically conditioned for release into the wild. Habitat conditions at release sites were presumably optimal, with abundant escape cover and natural foods. Predator numbers were not censused, but believed to be average and similar to those of the surrounding vicinity. Finally, we used the most recent release procedures recommended by private wildlife consultants currently involved in pen-raised bobwhite release programs. Despite following careful protocol, survival of game farm and F1 bobwhites in our study was extremely low. Our data, however, do not preclude the possibility that more satisfactory results might have been achieved by using a different source of birds or increasing efforts to control mammalian predators prior to release. Survival also might have been increased by "swamping" the release area with more birds than resident predator populations are capable of capturing, at least during the first several weeks post-release.

Costs must be considered when evaluating the feasibility of raising pen-raised bobwhites for restoration efforts. In our study, we purchased game farm and F1 bobwhites for $4 and $15 each. If we incorporate personnel and equipment costs associated with trapping wild birds for breeding purposes, the actual cost of each released F1 bobwhite was in excess of $50. We estimate the costs associated with each released wild-relocated bobwhite to be even higher, approximately $200 per bird. The cost of each ACRS units was $169.45. If survival rates observed in our study were representative, the high cost:benefit ratio of releasing or relocating bobwhites make it infeasible for establishing populations in most areas.

Game farm and F1 bobwhites in our study survived poorly because they appeared to lack behavioral skills necessary to escape predation. Even the "genetically wild" F1 birds were easily killed by predators, suggesting that the influences of being raised in captivity had a greater impact on survival than innate genetic programming. Ellsworth et al. (1988) also concluded that genetics were less important than rearing procedures in shaping pen-raised bobwhite performance in the wild. Almost every published study involving the release of pen-raised bobwhites, even those reporting much higher survival rates, describe post-release behavior similar to that which we observed. A common characteristic among some areas with successful releases seems to be the presence of a moderate or high wild bobwhite population prior to release. Pen-raised bird survival can apparently be enhanced by association with wild bobwhites. It is also important to note that most successful releases are on areas intensively managed for bobwhites where mammalian predators are often controlled.

More frequently, however, pen-raised bobwhites are released as a means of increasing populations on areas where wild bird numbers are low. Often, predator populations on these same areas have not been managed or reduced. Survival of pen-raised birds will likely be very poor under these circumstances, even when habitat conditions are optimal. Although pen-raised bobwhites are known to survive longer in some areas under certain circumstances, we would contend that a successful release is more often the exception than the rule. For this reason, our data suggest that the release of game farm or F1 bobwhites to restock depleted quail range is unjustified in most situations.

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