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Fate Of Captive-Reared Bobwhite Quail Released In Central Kentucky

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FATE OF CAPTIVE-REARED BOBWHITE QUAIL (*Colinus virginianus*) RELEASED IN CENTRAL KENTUCKY

By

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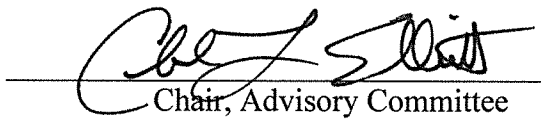

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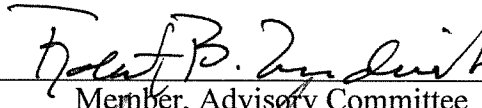

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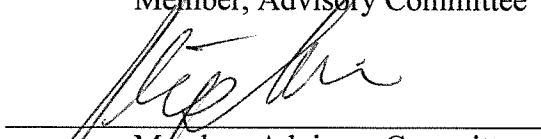

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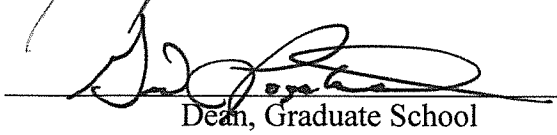

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FATE OF CAPTIVE-REARED BOBWHITE QUAIL RELEASED IN CENTRAL KENTUCKY

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ABSTRACT

The fate of pen-raised bobwhite quail (*Colinus virginianus*) released onto two farms (Site 1 and 2) and a reclaimed coal surface mine (Site 3) in south-central Kentucky during the summers of 2008 and 2009 was assessed. Of the 57 bobwhite quail radio-tagged and released in this study, the fate of 26 (45%) was unknown because the telemetry signal was lost and the birds could not be located. Within 34 days after release, mortality of the remaining 31 radio-tagged birds was 100%. Raptors, coyotes, and mesomammal predators were responsible for most (84%) of the identified quail mortality; accounting for the deaths of 12, 9, and 5 quail, respectively. There was no significant difference in mean length of survival for male vs female bobwhites at Site 1 (t=0.81, P=0.44), Site 2 (t=0.0, P=1.0), or Site 3 (t=0.28, P=0.78). For all sites combined, mean quail survival duration was greater in 2008 (6.7 + 6.4 days) than in 2009 (3.0 + 2.6 days), but not significantly greater (t=1.8, P=0.07). Correspondingly, mean survival duration (all sites combined) for males (7.0 + 8.5 vs 2.5 + 2.2 days) and females (6.7 + 6.4 vs 3.5 + 3.0 days) was greater in 2008 than in 2009, respectively; but the difference was not significant (t=1.67, P=0.12; t=0.94, P=0.36, respectively).

Similar to the general trend reported by other researchers, the mean survival duration for pen-raised bobwhite quail released into the wild in this study was low. Similar to what has been reported in studies across the southeast and midwest that monitored the fate of pen-raised quail released into the wild, predation was the main source of mortality for birds in this study. The high predation rates documented in this study, and the lack of wariness displayed by birds days after being released (pers. observ.) suggest pen-raised bobwhite quail lack predator avoidance behavior. Birds in this study exhibited little fear of humans, tended not to fly when approached by

people, walked in an erect posture [making them potentially conspicuous to predators], and were repeatedly observed in open areas away from cover.

Researchers have suggested that releasing pen-reared quail may actually threaten wild quail populations and other indigenous bird species in the release area. Issues such as the displacement of wild birds, disease transmission, increasing predator populations (by creating high densities of easily captured pen-reared birds), and altering the genetic composition of wild quail (diluting the wild gene pool via inbreeding with pen-raised birds), may individually or in combination negatively impact populations of resident bobwhite quail. Based on this study, releasing pen-raised bobwhite quail as a mechanism to increase quail populations in Kentucky does not appear to be a viable strategy.

TABLE OF CONTENTS

LIST OF TABLES

TABLE PAGE

LIST OF FIGURES

FIGURE PAGE

CHAPTER I

INTRODUCTION

The Northern Bobwhite (*Colinus virginianus*) is a species of quail native to the eastern and central United States (Burger et al. 2006). The Northern Bobwhite (referred to henceforth as bobwhite) has long been a popular species with sportsmen (Backs 1982) and remains one of the most widely studied species in North America (DeVos and Mueller 1993). Although once widespread and abundant within its range, bobwhite populations have declined sharply over the past 40 years, with a mean 3.0% per annum decrease from 1955 to 2005 (Sauer et al. 2005) within 75% of their native range (Brennan 1991), including the species' primary range in the southeastern states (Brennan 1991, Landers et al. 1991).

Habitat loss and degradation caused by human population growth, urbanization, land modifications for modern agriculture (e.g., "clean farming"), increased pesticide and fertilizer use, forest alterations, and reduced use of prescribed fire have been cited as causes for the decline of the Northern bobwhite quail (Backs 1982, Brennan 1991, Terhune et al. 2006, Hernandez et al. 2013). Of the habitat modifications considered most detrimental to bobwhite habitat in the southeastern United States, the conversion of grasslands and savannas comprised of native, warm-season clump grasses to pastures of nonnative, sod-forming grasses such as bermudagrass (*Cynodon dactylon*) and various fescues (*Festuca spp*.), may be the most significant. Sod-forming grasses restrict the movements of ground nesting birds, reduce insect biomass, outcompete valuable native forbs, and can cause endophyte toxicity when certain types of fescue seeds are consumed (Washburn and Barnes 2000, Harper 2007). The bobwhite population decline in the Ohio Valley region was further expedited by a series of severe winters in the late 1970s (Urban 1978, Backs 1982).

In the early 20th Century, landowners, conservation groups, and wildlife agencies began releasing captive bobwhite quail into the wild (Beuchner 1950, Sexson and Norman 1972, Backs 1982, Dowell 1992, Hurst et al. 1993, Kozicky 1993). The practice is somewhat controversial (Roseberry et al. 1987) since biologists consider captive-reared birds to be biologically inferior (Roseberry et al. 1987) and a possible threat to wild populations. However, the practice is viewed by a large segment of the general public as the primary solution to a complicated and primarily habitat-oriented problem (Backs 1982, Brennan 1991, Hurst et al. 1993); i.e., instant gratification superseding the long-term strategy to increase natural carrying capacity (Hurst et al. 1993).

Despite trends in scientific data (Roseberry et al. 1987), many sportsmen and landowners support releasing captive-reared bobwhites into the wild for multiple reasons (Landers et al. 1991). Although some releases are intended to augment harvestable numbers of birds (Sexson and Norman 1972, DeVos and Speake 1995, Hutchins and Hernandez 1993), the idea has persisted over the years that releases can restore or bolster natural populations (Baumgartner 1944, Brennan 1991). Landowners have attempted to improve bobwhite habitat through land use modifications and plant community alterations, without obtaining short-term population increases; hence the view that the release of captive-reared bobwhites into the wild is a way to "quickly" build up populations (Brennan 1991, Terhune et al. 2006). While translocations of captured wild bobwhites, ring-necked pheasants (*Phasianus colchicus*), and gray partridges (*Perdix perdix*) have proven somewhat successful (Dowell 1992, Terhune et al. 2006, Cass 2008), acquiring and translocating wild stock may be difficult; or even forbidden by state wildlife agencies (Brennan 1991, Cass 2008). As wild populations diminish, acquiring wild stock may become difficult and possibly detrimental to remaining populations (Dowell 1992). Several studies have been conducted to determine the efficacy of using captive-reared bobwhites to enhance declining natural populations (Baumgartner 1944, Barnes 1947, Phelps 1948, Sexson and Norman 1972, Backs 1982). The majority of data suggest mortality of released bobwhites is very

high, with little or no recruitment (Phelps 1948, Sexson and Norman 1972, Hutchins and Hernandez 2003). DeVos and Speake (1995) summarized varying overwinter survival rates from previous studies and noted the rate ranged from 1% (Beuchner 1950) to 58% (Frye 1942). Woolstenhulme (2001) found that in Kentucky, the average survival rate for released bobwhites was nine days; while Backs (1982) found that the mean survival for captive birds released in Indiana was eight days. The trend of poor recruitment notwithstanding, several instances of released birds surviving for extended periods of time have been recorded. Phelps (1948) reported one released male bobwhite survived for three years in the wild, and Barnes (1947) found one captive-reared bobwhite survived for eleven months after release. Baumgartner (1944) recorded several instances of released bobwhites surviving to the following season and producing broods, and observed females released prior to the onset of breeding season producing successful nests. Sexson and Norman (1972) and Perez et al. (2002) also observed captive birds being assimilated into the native population. While these reports may be rare, they provide evidence for prolonged survival by captive-reared birds in the wild; therefore, further investigation into the practice may be warranted.

Across its geographic range, the breeding dynamics, adult survival rates, and survival of nestlings are poorly understood aspects of bobwhite ecology (Devos and Mueller 1993, Hurst et al. 1996); particularly with captive-reared birds (Landers et al. 1991). Researchers have hypothesized that bobwhite chicks hatched in incubators may imprint upon each other rather than a parent, and that lack of parental care at the nestling stage may result in diminished survival behaviors (Dowell 1992, Perez et al. 2002). It is important to understand the causes of nest failure unique to bobwhite ecology; recruitment is paramount in maintaining viable populations (DeVos and Mueller 1993). In wild bobwhite populations, nest mortality is usually high, and can be a limiting factor locally (Hurst et al. 1996, Rollins and Carroll 2001, Rader et al. 2007) if predation

of sexually mature bobwhites is not mitigated by the survival of young birds to breeding age (Brennan 1991, Hurst et al. 1996).

The primary cause of mortality of adult and juvenile bobwhite quail is predation by snakes and mammalian predators, particularly mid-sized carnivores (Rollins and Carroll 2001), which can account for 75-81% of nest mortality in wild populations (DeVos and Mueller 1993, Rollins and Carroll 2001). Biologists believe that the loss of an interspersed mosaic of habitats (Brennan 1991, Hurst et al. 1996) has made bobwhites more susceptible to predation by creating overall favorable conditions for increased predator populations (Hurst et al. 1996, Rollins and Carroll 2001). These changes, coupled with the reduction in hunting and trapping of many bobwhite predators, have significantly increased predation upon bobwhites (Brennan 1991, Hurst et al. 1996). Burger et al. (1995) suggested that predation may vary between sexes of bobwhite quail; i.e., displaying males being targeted by raptors, while brooding females are more often taken by mammals.

Landowners and wildlife agencies that still release pen-raised bobwhite quail into the wild do so primarily in the months preceding hunting seasons (Sexson and Norman 1972, Kozicky 1987, Landers et al. 1991). Most of the investigations examining the survival of released bobwhites focused on birds released in the spring and fall months (Barnes 1947, Sexson and Norman 1972, Backs 1982, Mueller 1984, Woolstenhulme 2001, Hutchins and Hernandez 2003), and involved the release of large numbers of birds (Perez et al. 2002). Although data are inconclusive regarding the intensity of seasonal bobwhite mortality (Curtis et al. 1988, DeVos and Mueller 1993), the death of birds in the fall seems to be related to the loss of plant cover and abundance of some predators, specifically migratory raptors (Miller 2011). Studies focused on the release of captive bobwhites during the late spring and summer months are limited, but Baumgartner (1944) reported that 50% of released captive-reared birds survived until the fall hunting season, and estimated that 45% survived until the following spring.

Recent efforts to slow declining bobwhite populations have been undertaken by multiple state wildlife agencies working in cooperation with each other as well as non-governmental organizations (Morgan and Robinson 2008). In 2002, The National Bobwhite Conservation Initiative was formed to address population declines by conducting habitat improvement projects on large, contiguous tracts of land (National Bobwhite Technical Committee 2011). While this management strategy is practical and efficient, it excludes landowners who would like to increase bobwhite populations on smaller, fragmented properties.

The objectives of this study were: 1) to determine survival rate of captive-raised bobwhite quail released into the wild prior to breeding season; 2) to determine if released birds nested; and 3) if the birds did nest, to ascertain survival rates and recruitment of the F-1 generation into the wild.

CHAPTER II

STUDY AREAS

The study took place on private lands located in the Mississippian Plateau region in south-central Kentucky. The sites included 60 hectares of farmland in Lincoln County, 60 hectares of farmland in Pulaski County, and 60 hectares of reclaimed surface mine in Pulaski County.

The Pulaski County farmland study area (Site 1) was used primarily for grain farming, the main crops being corn, soybeans, and wheat, grown in rotation; as well as intermittent fallow habitat dominated by orchard grass (*Dactylis glomerata*), annual bluegrass (*Poa annua*), ironweed (*Vernonia gigantea*), Johnson grass (*Sorghum halapense*), goldenrod (*Solidago altissima*), and foxtail (*Setaria spp.*). The site was interspersed with fencerows overgrown with black locust (*Robinia pseudoacacia*), sumac (*Rhus spp.*), Japanese honeysuckle (*Lonicera japonica)*, and multiflora rose (*Rosa multflora*).

The reclaimed surface mine study area (Site 2) in Pulaski County supported an early successional grassland habitat interspersed with fragmented forest and brushy areas. Dominant plant species at this site included Chinese lespedeza (*Lespedeza cuneata*), blackberry (*Rubus argutus*), broomsedge (*Andropogon virginiana*), big bluestem (*Andropodon gerardii*), multiflora rose (*Rosa multiflora*), sumac (*Rhus spp.*), Virginia pine (*Pinus virginiana*), tulip poplar (*Liriodendron tulipifera*), and southern red oak (*Quercus falcata*). Site 2 represented a more shrub-dominated habitat type; however, it also possessed the greatest abundance of tall fescue (*Festuca elatior*).

The Lincoln County farmland study area (Site 3) was managed for white-tailed deer (*Odocoileus virginianus*), wild turkey (*Meleagris gallopavo*), and upland wildlife species (DeVos

and Speake 1995). Dominant plant species at this site included corn, wheat, grain sorghum, Johnson grass, Queen Anne's lace (*Daucus carota*), foxtail, aster (*Symphiotrichum dumosum*), multiflora rose, blackberry, raspberry (*Rubus occidentalis*), black walnut (*Juglans nigra*), and hackberry (*Celtis occidentalis*).

CHAPTER III

METHODS

Field work took place 15 April 2008 - 1 December 2010. The study began in May, two weeks prior to the peak bobwhite nesting season (Johnsgard 1973). The study sites were surveyed for native bobwhites by walking the area and flushing birds (Barnes 1947, Roseberry and Klimstra 1984) and by listening for bobwhite calls (Curtis et al. 1988). I observed no sign of wild bobwhites at any of the study sites.

Breeding adult captive-raised bobwhite quail were purchased from a game farm and transported in gamebird shipping cartons (Perez et al. 2002). Birds appeared to be healthy (Backs 1982), and were devoid of any obvious visible symptoms of known avian diseases (Landers et al. 1991). Bobwhites were fitted with radio collars (Miller 2011) containing mortality-sensitive transmitters (Wildlife Materials Inc., Murphysboro, IL; Shields and Mueller 1983, Curtis et al. 1988, DeVos and Speake 1995) and banded with numbered aluminum leg bands (National Band and Tag Co., Newport, KY; Stoddard 1931). Radio units were attached following the procedure outlined by Kooyman et al. (1982). This method appeared to limit interference with regular movements and eliminate the erratic behavior initially observed upon fitting (Garcelon 1977).

Bobwhites were released as male and female pairs on each study area in locations deemed to be suitable nesting habitat (Lusk et al. 2006). An attempt was made to release one pair of birds per 1.6 ha of habitat (DeVos and Speake 1995, Sisson et al. 2000). This resulted in the release of 5, 7, and 6 pairs at sites 1, 2, and 3, respectively, in 2008. Funding constraints resulted in the release of 4 pairs of birds at each site in 2009. The rationale for releasing one pair of quail per 1.6 hectares rather than releasing all the birds at once was that a mass release would be counterproductive in the available habitat (Curtis et al. 1988, Hurst et al. 1993), increase the birds'

stress levels (Dowell 1992), and attract predators, which have a density-dependent predation dynamic with bobwhites (Dowell 1992, Hurst et al. 1996, Rollins and Carroll 2001). Following the release, I monitored the sites three times per week (Curtis et al. 1988) to track movements of adult bobwhites. Movements of radio-tagged bobwhites were monitored and birds located via triangulation (Mueller et al. 1988) or homing (Hutchins and Hernandez 2003, Terhune et al. 2006).

I searched for nest sites in areas where adult bobwhites remained for longer than 48 hours (Lusk et al. 2006, Potter et al. 2011). Attempts were made to locate nest sites by having observers walk through areas while dragging a weighted rope and watching for birds to flush (Davis 2003, Kershner et al. 2004). I attempted to recover any dead radio-collared birds and determine the cause of death (Curtis et al. 1988, Sisson et al. 2000). When dead radio-tagged birds were located, the cause of death was assigned using the following criteria: Raptor [circular piles of bobwhite feathers present and/or evidence of beak marks on radio-transmitter housing (Curtis et al. 1988)]; Coyote (*Canis latrans*) [tracks/scat present, tooth marks on radio-transmitter housing, and/or radio-tags found buried, caching behavior indicative of predation by coyotes (Phillips et al. 1991, O'Donoghue et al. 1998)], Mesopredator [tracks/scat of raccoon (*Procyon lotor*), opossum (*Didelphis virginiana*), or house cat present], and Undetermined (evidence of predation was present, i.e., bird remains, but there was no definitive evidence to indicate what kind of predator was responsible).

Beginning twenty-three days after release (Potter et al. 2011), when the highest degree of fledgling mortality typically occurs (Johnsgard 1973), an attempt was made to capture quail using funnel traps (Miller 2011) baited with cracked corn (Stoddard 1931) or a lure [i.e., an electronic bobwhite call (Quality Wildlife Services Inc. Waynesboro, GA; Curtis et al. 1988). Trapping was conducted for the purpose of re-capturing any mature birds which may have become unaccounted

for due to a lost or defective transmitter. Study sites were trapped monthly (two week periods beginning 10-24 July 2008 and ending 1 March 2010) for the duration of the study period.

T-tests were used to compare mean survival rates of released adult male and female bobwhites; and male and female chicks born during the project. Nonparametric tests were used to compare survival among the three sites. Mortality for both groups was displayed in a life table (Krebs 1989). Significant values for statistical analyses were accepted at $P < 0.05$ and values depicted represent the mean ± one standard deviation.

Procedures related to northern bobwhite capture and handling were reviewed by Eastern Kentucky University's Institutional Animal Care and Use Committee and approved as Protocol #006-2008.

CHAPTER IV

RESULTS

Survival of radio-tagged, captive-raised, adult bobwhite quail released into the wild as part of this study was low. Of the 57 bobwhite quail radio-tagged and released in this study, the fate of 26 (45%) was unknown because the telemetry signal was lost and the birds could not be located (Tables 4-6)[1]. Within 34 days after release, mortality of the remaining 31 radio-tagged birds was 100% (Figs. 1-3). Raptors, coyotes, and mesopredators were responsible for most (84%) of the identified quail mortality; accounting for the deaths of 12, 9, and 5 quail, respectively (Tables 4-6). On one occasion, I encountered a timber rattlesnake (*Crotalus horridus*) coiled around the remains of a quail and the transmitter. Four birds were taken by undetermined predators (evidence of predation was present, i.e., bird remains, but there was no definitive evidence to indicate what kind of predator was responsible).

There was no significant difference in mean length of survival for male vs female bobwhites at Site 1 (t=0.81, P=0.44), Site 2 (t=0.0, P=1.0), or Site 3 (t=0.28, P=0.78). For all sites combined, mean quail survival duration was greater in 2008 (6.7 + 6.4 days) than in 2009 (3.0 + 2.6 days), but not significantly greater (t=1.8, P=0.07). Correspondingly, mean survival duration (all sites combined) for males (7.0 + 8.5 vs. 2.5 + 2.2 days) and females (6.7 + 6.4 vs. 3.5 + 3.0 days) was greater in 2008 than in 2009, respectively; but the difference was not significant (t=1.67, P=0.12; t=0.94, P=0.36, respectively). Despite extensive searches, no nests or nesting behavior by adults were observed.

[1] All tables and figures are found in the Appendix.

CHAPTER V

DISCUSSION

Similar to the general trend reported by other researchers (Phelps 1948, Backs 1982), the mean survival duration for pen-raised bobwhite quail released into the wild in this study was low. Within 34 days post-release >50% of the birds were dead. In Kentucky, Pierce (1951) found that over-winter survival of released quail was 7%. Woolstenhulme (2001) reported pen-raised birds released on a wildlife management area in Madison County, KY, exhibited a 30 day survival rate of 12%; and survived over-all an average of nine days. Backs (1982) reported pen-raised quail released in Indiana survived an average of eight days.

Across the southeastern and midwestern range of the bobwhite quail; where pen-raised birds have been released, predation has been the primary source of mortality (Barnes 1947, Phelps 1948, Roseberry et al. 1987, Curtis et al. 1988, Burger et al. 1995, DeVos and Speake 1995, Dixon et al. 1996, Perez et al. 2002). In this study, documented mortality of pen-raised quail released into the wild was mainly due to predation. Woolstenhulme (2001) reported mortality of pen-raised birds released in south-central Kentucky in both fall and spring were attributed mainly to predation.

The high predation rates documented in this study, and the lack of wariness exhibited by birds days after being released (pers. observ.) suggest pen-raised bobwhite quail lack predator avoidance behavior. Birds in this study exhibited little fear of humans, tended not to fly when approached by people, walked in an erect posture [potentially conspicuous to predators (Dowell 1992)], and were repeatedly observed in open areas away from cover. Kozicky (1993) noted predator recognition and avoidance in quail is learned and not typically exhibited by pen-raised birds. Ellsworth et al. (1988) reported electrophoresis experiments on wild, captive-reared, and F1 and F2 crosses, found only slight genetic differences and suggested that differing behavior of

captive bobwhites may be entirely learned. Roseberry et al. (1987) compared the survival of wild and pen-reared bobwhite quail and noted pen-reared birds exhibited little predator avoidance behavior. Dowell (1992) concluded the parental care received by captive-reared game birds did not endow the necessary behavior for survival in the wild, both in terms of predator avoidance and foraging behaviors.

The lack of documented nesting attempts by pen-raised quail released in this study may have been the result of interactions between predation, weather, and lack of appropriate behavior due to captive breeding. High temperatures and drought conditions occurred following the release of birds in the first season of this study; high winds and thunderstorms occurred immediately following releases in the second season. Weather strongly influences bobwhite nesting behavior and success (Baumgartner 1944, DeVos and Mueller 1993, Hurst et al. 1996).

CHAPTER VI

MANAGEMENT IMPLICATIONS

Pen-reared bobwhite quail in this study released onto agricultural land and reclaimed coal lands south-central Kentucky exhibited low survival rates. Such results indicate that raising and releasing quail may temporarily increase quail numbers, but has no long-term effect on supplementing wild populations. Researchers have suggested that releasing pen-reared quail may actually threaten wild quail populations and other indigenous bird species in the release area. Issues such as the displacement of wild birds (Sexson and Norman 1972, Landers et al. 1991), disease transmission (Brennan 1991, Landers et al. 1991, Hurst et al. 1993, Sisson et al. 2000), increasing predator populations by creating high densities of easily captured pen-reared birds (Hurst et al. 1993), and altering the genetic composition of wild quail by diluting the wild gene pool via inbreeding with pen-raised birds (Hurst et al. 1993), may individually or in combination negatively impact populations of resident bobwhite quail. Based on this study, releasing pen-raised bobwhite quail as a mechanism to increase quail populations in Kentucky does not appear to be a viable strategy. The habitat-focused approach to bobwhite quail management, as outlined in The National Bobwhite Conservation Initiative (National Bobwhite Technical Committee 2011) appears a better long-term solution to enhancing bobwhite numbers than releasing pen-raised birds. As pointed out by Hernandez et al. (2013).

> "Land use patterns that once sustained widespread abundance of northern bobwhite during the early 20th century clearly are past and likely never to return. Landscape

features that sustain and elevate northern bobwhite populations will only be maintained as a function of purposeful management actions directed at saving and creating usable space."

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APPENDIX

Table 1. Life table depicting mortality for captive-reared bobwhite quail released onto a farm in Pulaski County, Kentucky, (Site 1) June 2008 to March 2010.

Days *x* # alive at start, *nx*		Proportion alive, *lx*	# dying in x to x+1, *dx*	censored, *wx*	Mortality,*qx*	Survival, *px*
0	18	1.00	1	4	0.06	0.94
1	13	0.72	1	3	0.08	0.92
2	9	0.50	0	4	0.00	1.00
3	5	0.28	2	0	0.00	1.00
4	3	0.17	0	0	0.40	0.60
5	3	0.17	0	0	0.00	1.00
6	3	0.17	1	0	0.17	0.83
7	2	0.11	0	0	0.00	1.00
8	2	0.11	0	0	0.00	1.00
9	1	0.06	1	0	1.00	0.00
10	0	0.00	-	-	-	-

Table 2. Life table depicting mortality for captive-reared bobwhite quail released onto reclaimed coal mine land in Pulaski County, Kentucky, (Site2) June 2008 to March 2010.

Days *x*	# alive at start, *nx*	Proportion alive, *lx*	# dying in x to x+1, *dx*	censored, *wx*	Mortality, *qx*	Survival, *px*
0	22	1.00	5	4	0.23	0.77
1	13	0.59	1	2	0.08	0.92
2	10	0.46	1	1	0.10	0.90
3	8	0.36	3	1	0.38	0.62
4	4	0.14	0	4	0.00	1.00
5	0	0.00	-	-	-	-

Table 3. Life table depicting mortality for captive-reared bobwhite quail released onto a farm in Lincoln County, Kentucky, (Site 3) June 2008 to March 2010.

Days *x*	# alive at start, *nx*	Proportion alive,	# dying in x to x+1, *dx*	censored, *wx*	Mortality, *qx*	Survival, *px*
0	20	1.00	1	1	0.05	0.95
1	18	0.90	1	1	0.06	0.94
2	16	0.80	0	3	0.00	1.00
3	13	0.65	1	0	0.08	0.92
4	12	0.60	0	1	0.00	1.00
5	11	0.55	1	0	0.09	0.91
6	10	0.46	2	2	0.20	0.80
7	6	0.30	2	2	0.33	0.67
8	2	0.20	1	0	0.50	0.50
9	1	0.05	1	0	1.00	0.00
10	0	0.00	-	-	-	-

Table 4. Fate of pen-raised bobwhite quail released on a farm (Site 1) in Pulaski County, KY, 2008 and 2009.

Band #	Transmitter #	Sex	Release Date	Date of Mortality	Cause of Mortality
			2008		
6101	545	M	6-23-08	6-25-08	Lost[1]
6102	515	F	6-23-08	6-25-08	Lost
6103	645	M	6 -23-08	6-26-08	Lost
6104	386	F	6-23-08	6-26-08	Lost
6105	435	M	6-23-08	6-24-08	Raptor[2]
6106	465	F	6-23-08	6-26-08	Lost
6107	495	M	6-23-08	7-08-08	Lost
6108	513	F	6-23-08	6-25-08	Coyote[3]
6109	xxx	M	6-23-08	Escape	Unknown[4]
6110	405	F	6-23-08	6-30-08	Raptor
			2009		
6156	504	M	6-08-09	6-12-09	Raptor
6157	415	F	6-08-09	6-12-09	Raptor
6159	615	M	6-08-09	6-16-09	Coyote
6158	565	F	6-08-09	6-16-09	Coyote
6180	715	M	6-08-09	6-09-09	Undetermined[5]
6179	386	F	6-08-09	6-09-09	Lost
6178	836	M	6-08-09	6-11-09	Lost
xxxx	xxx	F	6-08-09	Escape	Unknown

[1] Lost: telemetry signal was lost and the birds could not be located.

[2] Raptor: circular piles of bobwhite feathers present and/or evidence of beak marks on transmitter housing.

[3] Coyote: tracks/scat present, tooth marks on transmitter housing, and/or radio unit buried.

[4] Unknown: bird escaped prior to being banded or radio-tagged.

Table 4 (continued)

[5] Undetermined: evidence of predation present, i.e., bird remains, but no definitive evidence to indicate what kind of predator was responsible.

Table 5. Fate of pen-raised bobwhite quail released on coal land (Site 2) in Pulaski County, KY, 2008 and 2009.

Band #	Transmitter #	Sex	Release Date	Date of Mortality	Cause of Mortality
			2008		
6112	335	M	6-28-08	7-02-08	Lost
6113	285	F	6-28-08	7-02-08	Coyote
6114	315	M	6-28-08	7-08-08	Lost
6115	195	F	6-28-08	7-08-08	Lost
6116	006	M	6-28-08	7-08-08	Lost
6117	256	F	6-28-08	7-08-08	Lost
6118	105	M	6-28-08	6-29-08	Mesopredator[1]
6119	145	F	6-28-08	6-29-08	Undetermined
6120	356	M	6-29-08	7-05 -08	Mesopredator
6121	583	F	6-29-08	7-05-08	Undetermined
6122	625	M	6-29-08	7-05-08	Raptor
6123	435	F	6-29-08	7-05-08	Raptor
6124	545	M	6-29-08	7-02-08	Lost
6125	065	F	6-29-08	7-02-08	Lost
			2009		
6167	956	M	6-09-09	6-10-09	Coyote
6168	495	F	6-09-09	6-10-09	Coyote
6169	105	M	6-09-09	6-10-09	Coyote
6170	785	F	6-09-09	6-12-09	Coyote
6171	715	M	6-09-09	6-10-09	Lost
6172	854	F	6-09-09	6-10-09	Lost
6176	465	M	6-09-09	6-10-09	Lost
61677	435	F	6-09-09	6-10-09	Lost

Table 5 (continued)

[1] Mesopredator: tracks/scat present.

Table 6. Fate of pen-raised bobwhite quail released on a farm (Site 3) in Lincoln County, KY, 2008 and 2009.

Band #	Transmitter #	Sex	Release Date	Date of Mortality	Cause of Mortality
			2008		
6126	495	M	7-13-08	7-16-08	Undetermined
6127	435	F	7-13-08	7-21-08	Failed Transmitter[1]
6128	145	M	7-13-08	8-01-08	Mesopredator
6129	105	F	7-13-08	7-23-08	Raptor
6130	405	M	7-13-08	7-21-08	Raptor
6131	956	F	7-13-08	7-23-08	Raptor
6135	765	M	7-13-08	7-21-08	Raptor
6133	895	F	7-13-08	7-23-08	Lost
6136	715	M	7-13-08	8-14-08	Mesopredator
6137	836	F	7-13-08	7-23-08	Lost
6141	925	M	7-13-08	8-17-08	Raptor
6142	785	F	7-13-08	7-16-08	Lost
			2009		
6162	645	M	6-08-09	6-10-09	Mesopredator
6161	384	F	6-08-09	6-10-09	Lost
6164	534	M	6-08-09	6-11-09	Undetermined
6163	365	F	6-08-09	6-15-09	Raptor
6166	xxx	M	6-08-09	Escape	Unknown
6165	585	F	6-08-09	6-16-09	Lost
6174	065	M	6-08-09	6-13-09	Coyote
6175	513	F	6-08-09	6-14-09	Failed Transmitter

[1] Failed transmitter: bird was actually seen, but transmitter emitted no signal.

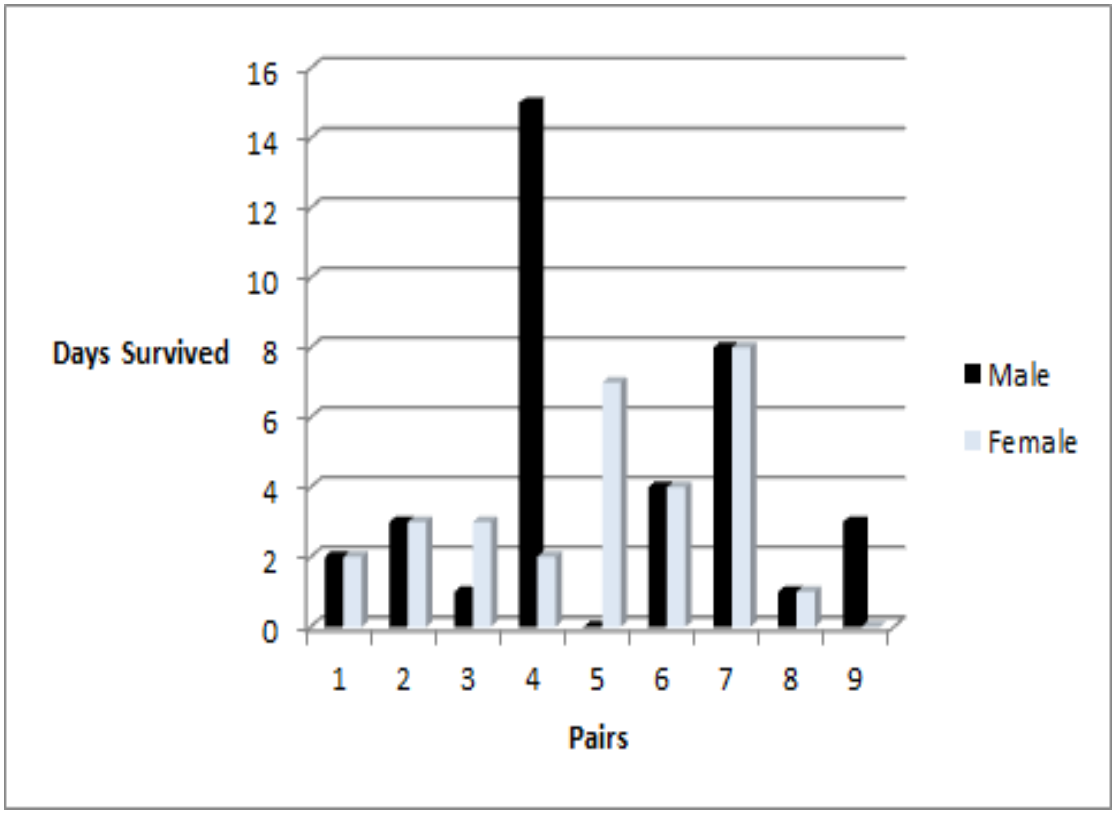

Figure 1. Survival of 9 pairs of radio-tagged captive-raised bobwhite quail released on a farm (Site 1) in Pulaski County, KY, 2008 and 2009.

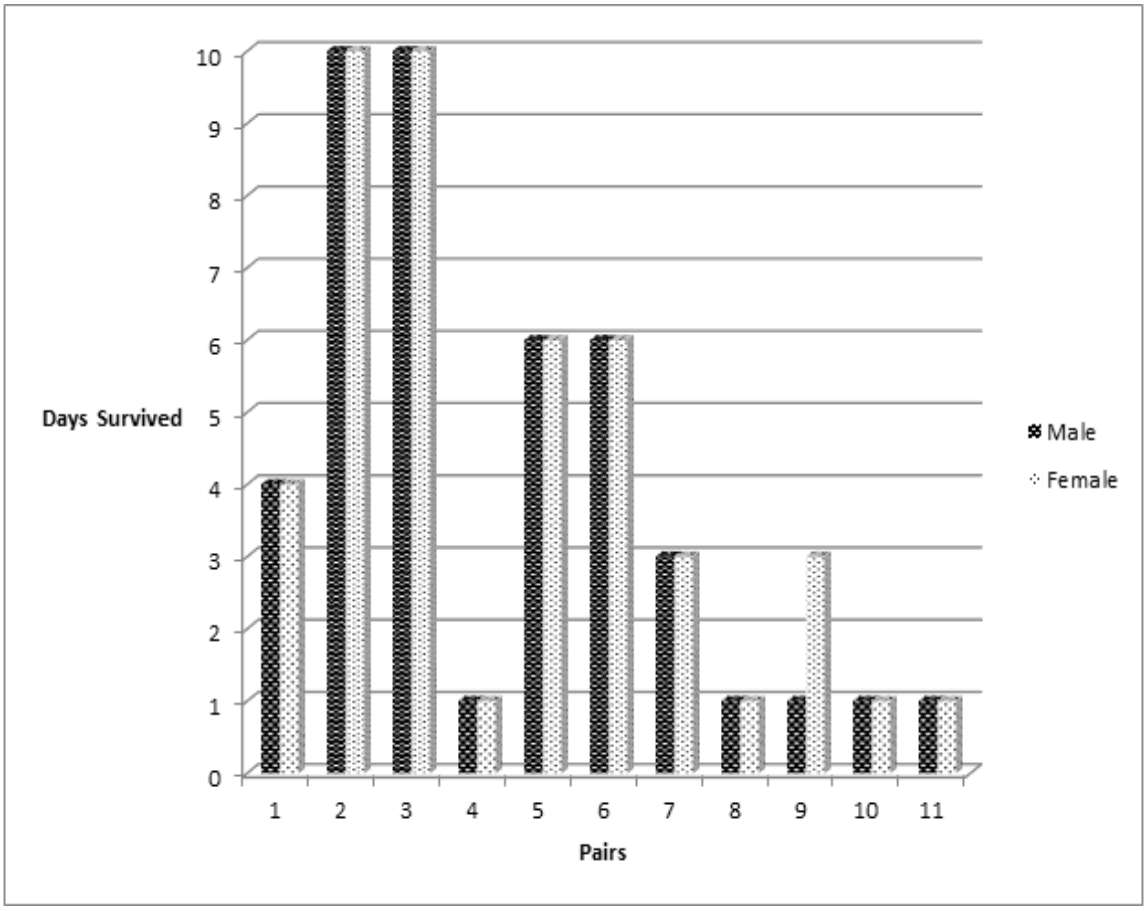

Figure 2. Survival of 11 pairs of radio-tagged captive-raised bobwhite quail released on reclaimed coal mine land (Site 2) in Pulaski County, KY, 2008 and 2009.

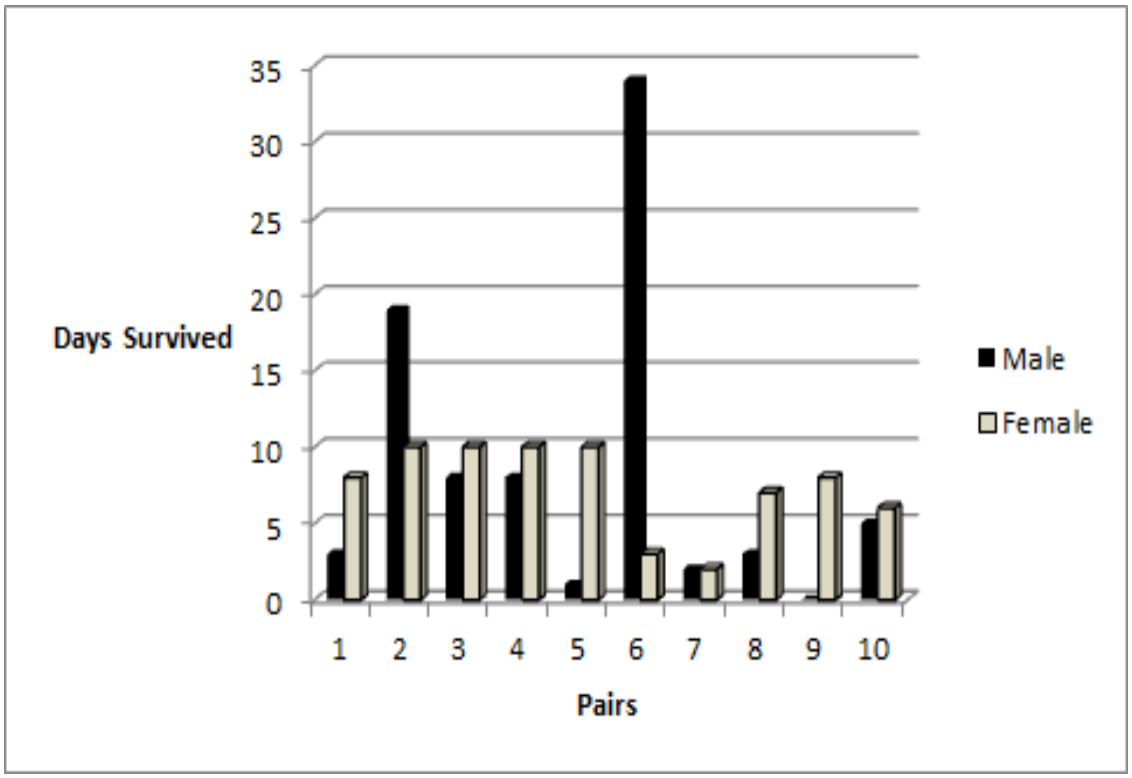

Figure 3. Survival of 10 pairs of radio-tagged captive-raised bobwhite quail released on a farm (Site 3) in Lincoln County, KY, 2008 and 2009.

Vita

Adam Carter was born in 1979 in Harlan, KY. He graduated from Pulaski County High School in 1997, and earned a Bachelor's of Science in Wildlife Management from Eastern Kentucky University in 2004.