EFFECTIVENESS OF THE SURROGATOR® AT INCREASING NORTHERN BOBWHITE ABUNDANCE AND ENHANCING HUNTING

By

JACOB HAGEN

Bachelor of Science

Murray State University

Murray, Kentucky

2009

Submitted to the Faculty of the
Graduate College of the
Oklahoma State University
in partial fulfillment of
the requirements for
the Degree of
MASTER OF SCIENCE
July, 2011

EFFECTIVENESS OF THE SURROGATOR® AT

INCREASING NORTHERN BOBWHITE ABUNDANCE

AND ENHANCING HUNTING

Thesis Approved:

Dr. Craig A. Davis

Thesis Adviser

Dr. Fred S. Guthery

Committee Member

Dr. R. Dwayne Elmore

Committee Member

Dr. Sheryl A. Tucker

Dean of the Graduate College

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER I

NORTHERN BOBWHITE DECLINE AND THE USE OF CAPTIVE-RELEASES FOR SPORT

INTRODUCTION

Bobwhite Decline

For more than a century, Northern Bobwhite (*Colinus virginianus*; hereafter, bobwhite) populations have been declining in many regions of the country (Guthery 2000). Across the southeastern U.S., bobwhite populations decreased by 66% between 1966 and 1999 (Sauer et al. 2000). Even bobwhite plantations in the Southeast, which are intensively managed for bobwhites, have reported unsatisfactory bobwhite populations (Evans et al. 2009). According to the Breeding Bird Survey (1966–2005), bobwhite populations have been declining at an average rate of 3.8% per year (McKenzie 2009). Landscape changes such as “clean” farming practices, suburban sprawl, and removal of disturbances such as fire and grazing are a few of the key reasons cited for the bobwhite decline (Brennan 1991, Roseberry 1993).

Life History

Bobwhite populations can exhibit wide variation due to their susceptibility to extreme weather and their ability to proliferate under ideal conditions (Guthery 2000). Annual population variations are due to a number of factors, but high annual mortality can play a large role. Annual bobwhite mortality was estimated to be around 70% in

Illinois, but it can range from 60-90% (Roseberry and Klimistra 1984, Sisson et al. 2009). Weather events play an important role in bobwhite abundance. In particular, rainfall is a critical factor that impacts bobwhite nesting success, and its wide fluctuations produce negative trends in bobwhite populations (Giuliano and Lutz 1993). Bobwhites suffer stress and dehydration when drought conditions prevail into the breeding season, and nesting is often times delayed or results in lower success (Stanford 1972). Snowfall can also harm bobwhite populations throughout their northern range by burying food supplies (Hawkins 1940, Roseberry and Klimistra 1984) and creating inhospitable conditions for the birds to survive.

Bobwhites are vulnerable to predation throughout their lives, especially during the nesting and brood-rearing stages (Sisson et al. 2009). Because bobwhites experience high annual mortality, nest success and chick survival is crucial to ensure population stability. Nest success from various parts of the bobwhite's range is generally around 35%, with losses primarily from nest abandonment and depredation (Lehmann 1946, Klimstra 1950a, Lantham and Studholme 1952, Klimstra and Scott 1957, Staller et al. 2002). Bobwhites will attempt to renest following an unsuccessful attempt; however, parental care, clutch size, and favorable weather conditions decrease as the season progresses (Rosene 1969). The mortality rate of chicks from hatching until 8 weeks old is about 30% (Klimstra 1950b), and chick mortality is largely influenced by habitat composition. Quality bobwhite habitat is a combination of dense bunch grass nesting cover, open weedy "bugging" areas, and thick loafing and escape cover (Stoddard 1931). These habitats increase survival by providing abundant food and protection. During the first 8 weeks, bobwhite chicks require bare ground intermixed with forbs and grasses, along with an abundance of invertebrates (Stoddard 1931, Martin et al. 2009). Bobwhite populations have the potential to overcome the high year-to-year variation within large suitable landscapes (4,000-12,000 ha). These large scale landscapes provide the means to persist through localized weather events, which are obstacles to bobwhite population stability. In abundant quality habitat, even bobwhite populations decimated by intense weather can rebound within a few years through successful reproductive efforts and immigration (Guthery 2000). However, these large continuous and connected parcels of quality habitat no longer exist in many regions of the bobwhite's range, resulting in a large decline in many of their populations.

Land Use Change

Because bobwhite populations initially adapted to early farming practices such as small scale tenant farming and rotational cropping, their populations thrived and as a result, many people began pursuing this abundant available quarry (Rosene 1969). Many families who retained a working relationship with the land and even those disconnected from it became intertwined with this popular gamebird as the hunting tradition was passed from generation to generation (Burger et al. 1999). Further, the proliferation of bobwhite populations across the southeastern U.S. attracted wealthy sportsmen who specifically journeyed there for the recreation of pursuing bobwhite quail (Stribling and Sisson 2009).

In parts of the southeastern U.S., healthy populations of bobwhite quail are of importance economically, ecologically, and recreationally (Thackston and Whitney 2001). This is especially the case in Georgia which has retained a strong tradition of bobwhite hunting. In 1964, Georgia bobwhite hunters numbered approximately 127,000, and these sportsmen harvested roughly 3.5 million birds (Georgia Game and Fish Commission Federal Aid Report 1965). However, by 2002, only 30,000 bobwhite hunters remained in the state with them harvesting 540,000 birds of which nearly 70% were pen-released (Nicholson 2003). This marked decline in the number of sportsmen pursuing bobwhites is not atypical of other states within the bobwhite's range and represents a considerable economic loss to rural communities, game agencies, and businesses. In areas that have been managed specifically for bobwhites and cater to fee hunters, supplemental income from those activities can be substantial (Tullos et al. 2007). Burger et al. (1999) reported that a 6.9% decrease in bobwhite hunters in the southeast from 1991–1992 constituted a loss or redistribution of $13,326,177 to local economies.

As farming practices shifted to large scale continuous cropping techniques, and bobwhite populations declined, bobwhite quail enthusiasts began managing habitat specifically for bobwhites. Intense bobwhite-specific habitat management is costly, approaching $150 per ha (Snipe 1994). For tight-budgeted state fish and game agencies, costly habitat practices are difficult to maintain if the return is not immediately obvious (Miller and Hay 1984). As a result, state fish and wildlife agencies as well as private citizens began to seek alternative routes to supplement and enhance quail populations aside from and in addition to habitat management techniques. An alternative that sportsmen and conservationists have adopted is releasing pen-raised birds. There are 2 main drivers behind releasing pen-raised birds: provide gamebird hunting for the sportsman and supplement or restore a wild population (Baumgartner 1944). According to a review by Buechner (1950) approximately 20 states have released pen-raised bobwhites, and state game farming reached its peak around the mid 20th century.

Captive-rearing

A variety of bird species of conservation concern have been bred in captivity and later released in the wild with mediocre levels of success. In hope of overcoming high mortality during the incubation stage, gray partridge (*Perdix perdix*) eggs were removed from wild nests, hatched under a surrogate mother, and then replaced under the natural mother in the wild (Browne et al. 2009). This method was successful enough that some estate owners were able to sustain greater levels of hunting than non-managed estates, but due to high labor costs this practice has largely been abandoned in the 21st century (Browne et al. 2009). The masked bobwhite (*Colinus virginianus ridgwayi*) and Attwater's prairie chicken (*Tympanuchus cupido attwateri*) are other examples of upland birds of concern that have been bred in captivity in an effort to later restock the species in optimal habitat (Kuvlesky et al. 2000, Morrow 2004). These release programs were minimally successful as both species remain critically endangered.

In terms of rearing bobwhite quail in captivity, many studies have concluded that from a population restoration and supplemental harvest standpoint, the release of conventionally raised captive bobwhites is not a sustainable option (Roseberry et al. 1987, DeVos and Mueller 1989, DeVos and Speake 1995). These studies reached this conclusion because liberated bobwhites were not able to survive and reproduce at self-sustaining levels. Introduction of disease to wild bobwhites and loss of genetic diversity through pen and wild bobwhite interbreeding are other concerns of researchers (Erbeck and Nunn 1999, Evans et al. 2009). Annual survival rates of self-sustaining wild bobwhite populations range from 20–30%, whereas annual pen-reared survival is generally around 2% (Guthery 2000). Low survival rates may be associated with poor habitat selection by pen-released birds. Wild bobwhites generally stay within 75 m of brushy escape coverts as a refuge from predators (Kassinis and Guthery 1996). Perhaps low survival of pen-reared bobwhites is tied to inexperience in escape cover selection. Return rates of banded bobwhites released preseason have ranged from 10–35%, far lower than desirable, as sportsmen want to recover as much of their investment as possible (Beuchner 1950, Webb and Nelson 1971, Maple and Silvy 1988).

The release of pen-raised upland birds to furnish sport for hunters has been employed for centuries (Browne et al. 2009). In the U.S. and abroad, the depletion of game populations has made it necessary to restock gamebirds for hunting, which is mostly accomplished by captive releases (Buner 2009). The conventional release system is defined as hatching and raising chicks in a confined enclosed unit with limited exposure to the elements. As the chicks near adulthood, they are transported from their game farm locale to the release field and liberated prior to the hunting season (DeVos and Speake 1995). An additional step to the above mentioned system includes the same process with the use of a flight pen or larger area enclosed by a type of netting that exposes birds to the elements while preventing mammalian or avian predators from attacking them (Erbeck and Nunn 1999). Birds are kept in this enclosure as a way to produce flight capabilities superior to birds strictly kept in pens.

As Wiens and Rottenberry (1981) described, many biologists believe that given optimal habitat, bobwhite populations will replenish themselves by moving from areas of high density to areas of low density. However, in an increasingly fragmented landscape, isolated pockets of good quality, restored habitat are frequently separated from sources of potential recruitment. Frustrated by lack of results after habitat management and eager for quick results, many landowners acquire pen-raised birds to restock their land and provide huntable birds on their property.

Pen-raised birds released shortly prior to hunting have been shown to have varying survival characteristics compared to their wild counterparts. Previous pen-released bobwhite quail studies have reported fall to spring survival estimates generally ranged from 10-30% (Roseberry et al. 1987, Devos and Speake 1995, Evans et al. 2009). One study found that compared to a wild population, pen-raised quail incurred approximately 20% higher mammalian predation, possibly due to their observed reluctance to flush (DeVos and Speake 1995). Other researchers studying predator population indices on bobwhite-release sites and control sites found no difference in population indices between fields (Hutchins and Hernandez 2003).

Sportsmen criticize recently released pen-raised birds for being habituated and poor flyers (Seal 1977, Kozicky 1993). Hunting preserve owners who continually cycle large groups of bobwhite quail hunters through their properties need ample bobwhite populations that provide consistent satisfactory recreation for their guests (DeVos and Speake 1995, Guthery 2000, Evans et al. 2009). Unless the owner possess a substantial amount of intensively managed land, this is impossible to do without releasing pen-raised birds. Preserve managers have learned to avoid releasing their game farm bobwhites too early before the hunting season as they tend to disperse erratically and suffer high mortality, thus many now begin releasing pen-reared birds minutes prior to the hunt (Berger 1977). The positive aspect of releasing birds prior to the hunt is that few birds will be lost to predation or dispersal in such a short time interval, but the negative aspect is that the birds have insufficient time to acquire wild behavior that many hunters desire.

One way to measure dispersal is by using home range estimators. Oakley et al. (2002) reported a mean home range for pen-raised bobwhites of 36 ha. This figure is comparable to Eggert et al. (2009) who reported a mean pen-raised bobwhite quail home range of 28.4 ha. Other home range studies for wild bobwhites report a range of figures from 4.2–36.6 ha (Wiseman and Lewis 1981, Bell et al. 1985, Dixon et al. 1996, and Mueller et al. 1997). These numbers indicate if a landowner would like to establish multiple coveys of bobwhites on his property that he will need to own a sizable amount of land or provide better quality habitat for bobwhites in less space.

Not all reports of captive-released birds are negative. DeVos and Speake (1995) showed that contrary to Brennan (1991), pen-raised bobwhites will not displace wild bobwhites, and over time, coveys will usually consist of a combination of wild and pen-raised birds (Kozicky 1993). Pen-raised birds that survive to the hunting season after a substantial period of acclimation (1–2 months in the wild after liberation) have been shown to fly stronger and farther, hold better, and flush as a covey compared to birds given a shorter acclimation period (DeVos and Speake 1995). However, despite these positive attributes, many sportsmen are unsatisfied with their releases of game farm bobwhites, and continue to seek new captive release techniques.

The Surrogator

The surrogator was developed as a bird propagation technique that aimed to eliminate traditional problems with pen-released birds. The surrogator is a self-contained "surrogate mother" that provides food, water, heat, and protection for chicks for 5 weeks. The manufacturer of the surrogator claims it is dissimilar to conventional systems of captive rearing in that bobwhites are raised in isolation from humans, released at a time period of higher survivability, purportedly acquire “wild” behavior (e.g., strong flight, holds for dogs), and imprint to the surrounding property (Anonymous 2008). Thus, the surrogator as a non-traditional system for bird propagation should be investigated as a potential restoration or supplemental hunting tool.

OBJECTIVES

Evaluating the surrogator

The surrogator is designed to establish huntable populations of bobwhites on a property (Wildlife Management Technologies 2009). Owing to the continued decline of bobwhites across their range and the proliferation of releasing inadequate pen-reared birds, the surrogator is a potentially useful tool in bobwhite quail management and reintroduction. As little research has been published to verify the effectiveness of this technique, it is necessary to determine the usefulness of the system.

Despite adequate knowledge about their life history and persistent management efforts, bobwhites have continued to decline throughout their range (McKenzie 2009). One member of the quail family, the masked bobwhite, has even been depleted to the point that captive rearing and propagating programs need to be developed to ensure their survival (Kuvlesky et al. 2000). Many quail enthusiasts and researchers are hoping bobwhite populations do not decline to the point that captive-releases are required to ensure the survival of the species. Many hypotheses have been given to explain the decline in quail populations, but loss of habitat is the most accepted cause (Guthery 2000). Recently many shooting preserves have opened to provide hunting opportunities to sportsmen who retain the passion to hunt bobwhites and have little chance to do so elsewhere (Kozicky 1993). Due to the sheer number of hunters that many of these facilities accommodate, the release of pen-raised birds is necessary to satisfy hunter demand (Evans et al. 2009). However, the substitution of pen-raised birds in lieu of wild birds has not been favorably received by some hunters. Thus, many preserves continue searching for pen-reared quail that act and perform more like their wild counterparts (Kozicky 1993).

The manufacturer of the surrogator claims it is a new approach to the traditional system of pen raising bobwhites. The manufacturer claims the surrogator is different in many aspects from conventional game bird farming by allowing the chicks to acclimate to the desired locale, rearing chicks in near isolation from humans, and releasing the birds before survival instincts are lost (Wildlife Management Technologies 2009). By limiting the range of a species to a desired locale, the species is more likely to remain there as evidenced by trumpeter swans (*Cygnus buccinators*) that were transplanted and kept in semi-captive enclosures to acclimate them to the area (Monnie 1966). This same principle is applied to the surrogator and is used to attempt to instill fidelity to the area in which the bobwhites will eventually be released. Bobwhites have high mortality during the nesting and brooding stage (Sisson et al. 2009), but a potential benefit of the surrogator is that it effectively bypasses this stage and allows for release of chicks during a time period of lower mortality (Cox et al. 2004). The goal of the surrogator is to establish a population of “wild-like” birds that can avoid predators, forage successfully, remain on a property, acquire behavior similar to those of wild birds, and provide satisfactory recreation for the sportsmen (Wildlife Management Technologies 2009). Thus, the surrogator may appeal to sportsmen who are interested in restoring bobwhite populations on their property or enhancing hunting opportunities. Currently, the effectiveness of the surrogator as a viable option for restoring bobwhite populations and enhancing hunting opportunities has not been evaluated by an independent party.

The primary objectives of the study were:

1. Evaluate 35-day survival of Northern Bobwhite chicks while in the surrogator.
2. Evaluate post-release survival and habitat-use of surrogator chicks using radio transmitters for up to 8 weeks.
3. Assess quality of hunts and evaluate success of surrogator at enhancing hunting opportunities by monitoring hunts and recovering bands.

The main objectives of Chapter 2 were to estimate the survival of bobwhite chicks while in the surrogator and post-release. Specifically, I compared surrogator chick survival to previous published literature on pen-released and wild bobwhite. Because habitat composition is a critical component of bobwhite survival, I took vegetation measurements at transmittered chick locations to describe the type of habitat surrogator bobwhite chicks used. Dispersal off-site by released bobwhites may hamper sportsmen's ability to recoup the birds. I used global positioning systems (GPS) locations to plot where surrogator bobwhites from each unit established their home range. Previous researchers have observed predators converging on bobwhite release sites and to determine if that occurs in this study, I indexed predator abundances on release and control sites (Oakley et al. 2002). Invertebrates are a primary component of early chick's diet and I sampled each research field to record invertebrate abundance and seasonal peak invertebrates mass. Call counts were used to track population changes between years and sites. Chapter 2 was written as a manuscript for submission to the Wildlife Society Bulletin.

The objective of chapter 3 was to determine the influence of surrogator bobwhites on hunter success. Using unique metal leg bands, I determined which harvested bobwhites were surrogator birds and from which unit and time they were released. I also circulated a questionnaire asking hunters to rate how well surrogator bobwhites compared to wild quail. Using these above methods, I compared the surrogator propogation and releasing technique with other methods to provide sportsmen with independent information on the technique. Chapter 3 also was written as a manuscript for submission to the Wildlife Society Bulletin.

LITERATURE CITED

Anonymous. 2008. Wildlife management technologies 2009 surrogator system guide. Wildlife Management Technologies, Wichita, Kansas, USA.

Baumgartner, F. M. 1944. Dispersal and survival of game farm bobwhite quail in northcentral Oklahoma. Journal of Wildlife Management 8:112–118.

Bell, B., K. Dancak, and P. J. Zwank. 1985. Range, movements, and habitat use by bobwhites in southeastern Louisiana pinelands. Proceedings of the Annual Conference of Southeastern Association of Fish and Wildlife Agencies 39:512–519.

Berger, A. J. 1977. Fitness of offspring from captive populations. Pages 315-320 *in* S. A. Temple, editor. Endangered birds: management techniques for preserving threatened species. University of Wisconsin, Madison, USA.

Beuchner, H. K. 1950. An evaluation of restocking with pen-reared bobwhite. Journal of Wildlife Management 14:363–377.

Brennan, L. A. 1991. How can we reverse the northern bobwhite population decline. Wildlife Society Bulletin 19:544–555.

Browne, S. J., F. Buner, and N. J. Aebischer. 2009. A review of gray partridge restocking in the United Kingdom and its implications for the United Kingdom biodiversity action plan. Pages 380 – 390 *in* S. B. Cedarbaum, B. C. Faircloth, T. M. Terhune, J. J. Thompson, J. P. Carroll, editors. Gamebird 2006: Quail VI and Perdix XII. 31 May– 4 June 2006. Warnell School of Forestry and Natural Resources, Athens, Georgia, USA.

Buner, F. 2009. How to re-introduce gray partridges - conclusions from a releasing project in Switzerland. Pages 391 – 395 *in* S. B., Cedarbaum, B. C., Faircloth, T. M., Terhune, J. J., Thompson, and J. P., Carroll, editors. Gamebird 2006: Quail VI and Perdix XII. 31 May - 4 June 2006. Warnell School of Forestry and Natural Resources, Athens, Georgia, USA.

Burger, L. W., D. A. Miller, and R. I. Southwick. 1999. Economic impacts of northern bobwhite hunting in the southeastern U. S. Wildlife Society Bulletin 27:1010–1018.

Cox, S. A., A. D. Peoples, S. J. DeMaso, J. J. Lusk, and F. S. Guthery. 2004. Survival and cause-specific mortality of northern bobwhites in western Oklahoma. Journal of Wildlife Management 68:663–671.

DeVos, T., and B. S. Mueller. 1989. Reproductive ecology of northern bobwhite in north Florida. Pages 83–90 *in* K. E. Church and T. V. Dailey editors. Quail III: national quail symposium. Kansas Department Wildlife and Parks, Pratt, Kansas, USA.

DeVos, T., and D. W. Speake. 1995. Effects of releasing pen raised northern bobwhites on survival rates of wild populations of northern bobwhites. Wildlife Society Bulletin 23:267–273.

Dixon, K. R., M. A. Horner, S. R. Anderson, W. D. Henriques, D. Durham, and R. J. Kendall. 1996. Northern bobwhite habitat use and survival on a South Carolina plantation during winter. Wildlife Society Bulletin 24:627–635.

Eggert, D. A, B. S., Mueller, L. Robinette, and S. D. Wellendorf. 2009. Comparison of survival, productivity, movements, and habitat use of pre-season released quail on wild northern bobwhites on Groton Plantation, South Carolina. Pages 396 – 408 *in* Cederbaum S. B., Faircloth B. C., Terhune T. M., Thompson J. J., Carroll J. P., eds. Gamebird 2006: Quail VI and Perdix XII. 31 May – 4 June 2006. Warnell School of Forestry and Natural Resources, Athens, GA, USA.

Erbeck, D. H., and S. A. Nunn. 1999. Chlaydiosis in pen raised bobwhite quail (*Colinus virginianus*) and chukar partridge (*Alectoris chukar*) with high mortality. Avian Diseases 43:798–803.

Evans, K. O., M. D., Smith, L. W. Burger Jr., R. J., Chambers, A. E., Houston and R. Carlisle. 2009. Release of pen-reared bobwhites: potential consequences to the genetic integrity of resident wild populations. Pages 121–133 *in* S. B. Cedarbaum, B. C. Faircloth, T. M. Terhune, J. J. Thompson, J. P. Carroll, editors. Gamebird 2006: Quail VI and Perdix XII. 31 May – 4 June 2006. Warnell School of Forestry and Natural Resources, Athens, Georgia, USA.

Georgia Game and Fish Commission. 1965. Annual report: federal aid in wildlife restoration research. Georgia Game and Fish Commission, Atlanta, Georgia, USA.

Giuliano, W. M., and R. S. Lutz. 1993. Quail and rain: what's the relationship. Pages 64–68 *in* K. E. Church and T. V. Dailey, editors. Quail III: national quail symposium. Kansas Department of Wildlife and Parks, Pratt, Kansas, USA.

Guthery, F. S. 2000. On bobwhites. Texas A&M University, College Station, Texas, USA.

Hawkins, A. S. 1940. A wildlife history of Faville Grove, Wisconsin. Transactions of the Wisconsin Academy of Sciences, Arts, and Letters 32:29–65.

Hutchins, A. R. and F. Hernandez. 2003. Effects of pen-raised northern bobwhite introductions on wild bobwhites in south Texas. Proceedings of the Annual Conference of Southeastern Fish and Wildlife Associations 57: 181–191.

Kassinis, N. I. and F. S. Guthery. 1996. Flight behavior of northern bobwhite quail. Journal of wildlife management 60:581–585.

Klimstra, W. D. 1950a. Notes on bob-white nesting behavior. Iowa Bird Life 20:2–7.

Klimstra, W. D. 1950b. Bob-white quail nesting and production in southeastern Iowa. Iowa State College Journal of Science 24:385–395.

Klimstra, W. D., and T. G. Scott. 1957. Progress report on bobwhite nesting in southern Illinois. Proceedings of the annual conference-Southeastern Association of Game and Fish Commissioners 11:351–355.

Kozicky, E. L. 1993. The history of quail management with comments on pen-rearing. Pages 1–7 *in* K. E. Church and T. V. Dailey, editors. Quail III: national quail symposium. Kansas Department Wildlife and Parks, Pratt, Kansas, USA.

Kuvlesky, W. P., S. A. Gall Jr., S. J. Dobrott, S. Tolly, F. S. Guthery, S. A. DeStefano, N. King, K. R. Nolte, N. J. Silvy, J. C. Lewis, G. Gee, G. Camou Luders, and R. Engel-Wilson. 2000. The status of masked bobwhite in the United States and Mexico. Pages 42–57 *in* L. A. Brennan, W. E. Palmer, L. W. Burger and T. L. Pruden, editors.Quail IV : Proceedings of the Fourth National Quail Symposium. Tall Timbers Research Station , Tallahassee, Florida, USA.

Lantham, R. M., and C. R. Studholme. 1952. The bobwhite quail in Pennsylvania. Pennsylvania Game News Special Issue 4. Pennsylvania Game Commission, Harrisburg, Pennsylvania, USA.

Lehmann, V. W. 1946. Bobwhite quail reproductions in southwestern Texas. Journal of Wildlife Management 10:111–123.

Maple, D. P. and N. J. Silvy. 1988. Recovery and economics of pen-reared bobwhites in north-central Texas. Proceedings of the Annual Conference of Southeastern Fish and Wildlife Associations 42: 329–332.

Martin, N. C., J. A. Martin, and J. P. Carroll. 2009. Northern bobwhite brood habitat selection in south Florida. Pages 88–97 *in* S. B. Cedarbaum, B. C. Faircloth, T. M. Terhune, J. J. Thompson, J. P. Carroll, editors. Gamebird 2006: Quail VI and Perdix XII. 31 May – 4 June 2006. Warnell School of Forestry and Natural Resources, Athens, Georgia, USA.

McKenzie, D. F. 2009. Taking the northern bobwhite conservation initiative to the next level. Pages 16–23 *in* S. B. Cedarbaum, B. C. Faircloth, T. M. Terhune, J. J. Thompson, J. P. Carroll, editors. Gamebird 2006: Quail VI and Perdix XII. 31 May – 4 June 2006. Warnell School of Forestry and Natural Resources, Athens, Georgia, USA.

Miller, J. R., and M. J. Hay. 1984. Estimating substate values of fishing and hunting. Transactions of the North American Wildlife and Natural Resources Conference 49:345–355.

Monnie, J. B. 1966. Reintroduction of the trumpeter swan to its former prairie breeding range. Journal of Wildlife Management 30:691–696.

Morrow, M. E., T. A. Rossignol, and N. J. Silvy. 2004. Federal listing of prairie grouse: lessons from Attwater's prairie chicken. Wildlife Society Bulletin 32:112–118.

Mueller, B. S., L. Robinette, and J. Wilson. 1997. Progress report number 2: a study to determine the impacts of pen-raised bobwhites on native quail populations. Clemson University, Clemson, South Carolina.

Nicholson, W. S. 2003. Harvest of wildlife in Georgia. Federal Aid Project W-55, Georgia Wildlife Surveys. Georgia Game and Fish Commission, Atlanta, Georgia, USA.

Oakley, M. J., D. L. Bounds, T. A. Mollett, and E. C. Soutiere. 2002. Survival and home range estimates of pen-raised northern bobwhites in buffer strip and non-buffer strip habitats. Pages 74–80 *in* S. J. DeMaso, W. P. Kuvlesky, Jr., F. Hernandez, and M. E. Berger, eds. Quail V: Proceedings of the Fifth National Quail Symposium. Texas Parks and Wildlife Department, Austin, TX, USA.

Rosene, W. 1969. The bobwhite quail: It's life and management. Rutgers University, New Brunswick, New Jersey, USA.

Roseberry, J. L. 1993. Bobwhite and the "new" biology. Pages 16–20 *in* K. Church and T. Dailey, editors. Quail III: National Quail Symposium. Kansas Department of Wildlife and Parks, Pratt, Kansas, USA.

Roseberry, J. L. and W. D. Klimstra. 1984. Population ecology of the bobwhite. Southern Illinois University, Carbondale and Edwardsville, Illinois, USA.

Roseberry, J. L, D. L. Ellsworth, and W. D. Klimstra. 1987. Comparative post release behavior and survival of wild, semiwild, and game farm bobwhites. Wildlife Society Bulletin 15:449–455.

Sauer, J. R., J. E. Hines, and J. Fallon. 2000. The North American breeding bird survey, results and analysis 1966–1999. Version 2000.2. U.S. Geological Survey Patuxtent Wildlife Research Center, Laurel, Maryland, USA.

Seal, U. S. 1977. The noah's ark problem: multigenerational management of wild species in captivity. Pages 303–314 *in* S. A. Temple, editor. Endangered birds: management techniques for preserving threatened species. University of Wisconsin, Madison, Wisconsin, USA.

Sisson, D.C., T. M. Terhune, H. L. Stribling, J. F. Sholar, and S. D. Mitchell. 2009. Survival and causes of mortality for northern bobwhites in the southeastern USA. Pages 467 – 478 *in* S. B. Cedarbaum, B. C. Faircloth, T. M. Terhune, J. J. Thompson, J. P. Carroll, editors. Gamebird 2006: Quail VI and Perdix XII. 31 May – 4 June 2006. Warnell School of Forestry and Natural Resources, Athens, Georgia, USA.

Snipe, N. G. 1994. Economics and demographics. Pages 2.1–2.33 *in* J. E. Hodges, editor. A comprehensive study of a portion of the Red Hills region of Georgia. The Thomas College, Thomasville, Georgia, USA.

Stanford, J. A. 1972. Bobwhite quail population dynamics: relationships of weather, nesting, production patterns, fall population characteristics, and harvest in Missouri quail. Pages 115–139 *in* J. A. Morrison and J. C. Lewis, editors. Quail I: Proceedings of the first national bobwhite quail symposium. Oklahoma State University, Stillwater, Oklahoma, USA.

Stoddard, H. L. 1931. The bobwhite quail: its habits, preservation, and increase. Charles Scribner's Sons, New York, New York, USA.

Staller, E. L., W. E. Palmer, and J. P. Carroll. 2002. Macrohabitat composition surrounding successful and depredated northern bobwhite nests. Pages 61–64 *in* S. J. DeMaso, W. P. Kuvlesky, Jr., F. Hernandez, and M. E. Berger, editors. Quail V: Proceedings of the Fifth National Quail Symposium. Texas Parks and Wildlife Department, Austin, Texas, USA.

Stribling, H. L, and D. C. Sisson. 2009. Hunting success on Albany, Georgia plantations: the Albany quail project's modern quail management strategy. Pages 338 – 347 *in* S. B. Cedarbaum, B. C. Faircloth, T. M. Terhune, J. J. Thompson, J. P. Carroll, editors. Gamebird 2006: Quail VI and Perdix XII. 31 May – 4 June 2006. Warnell School of Forestry and Natural Resources, Athens, Georgia, USA.

Thackston, R. E., and M. Whitney. 2001. The bobwhite quail in Georgia: History, biology and management. Miscellaneous publication, Georgia Department of Natural Resources, Social Circle, Georgia, USA.

Tullos, T. A., W. D. Jones, B. D. Leopold, A. E. Houston, M. S. Whittington, A. T. Rohnke, and K. M. Jacobs. Integration of natural resources enterprises and the economic potential for Ames plantation. Proceedings of the annual conference-Southeastern Association of Game and Fish Commissioners 61:142.

Webb, L. G. and F. P. Nelson. 1971. Recovery data from pen-raised quail released before and during the hunt season. Proceedings of the Annual Conference of Southeastern Fish and Wildlife Associations 25:140–147.

Wiens, J. A., and J. T. Rottenberry. 1981. Censusing and the evaluation of avian habitat occupancy. Pages 522–532 *in* C. J. Ralph and J. M. Scott, editors. Estimating numbers of terrestrial birds. Cooper Ornithological Society, Lawrence, Kansas, USA.

Wildlife Management Technologies. Surrogate propogation; 2009. <http://www.wildlifemanagementtechnologies.com/sparticle.html> Accessed 28 January 2010.

Wiseman, D. S. and J. C. Lewis. 1981. Bobwhite use of habitat in tallgrass rangeland. Wildlife Society Bulletin 9:248–255.

CHAPTER II

SURVIVAL AND HABITAT USE OF SURROGATOR®-RELEASED NORTHERN BOBWHITE

Jacob Hagen, Lee Hamm, Craig Davis and Fred S. Guthery
Department of Natural Resource Ecology and Management, Oklahoma State University, 008C Agricultural Hall, Stillwater, OK 74078

Abstract: As northern bobwhite (*Colinus virginianus*) populations decline, sportsmen have experimented with captive-rearing techniques that produce bobwhites similar in characteristics to wild birds. The Surrogator® (hereafter, surrogator) is a recently developed captive-rearing system that claims to produce bobwhites similar in characteristics to wild birds and establish a huntable population of bobwhites within a property. As little research has been conducted to inform land managers and sportsmen on the effectiveness of this system, we evaluated the use of the surrogator from May–October 2009–2011 in Kiowa County, Kansas. We evaluated the surrogator according to the following primary objectives: in-surrogator survival; predator response to surrogator; and post-release survival, dispersal, and habitat use. We monitored in-surrogator survival by weekly checking the surrogator and recording mortalities. Predator response to the surrogator was monitored using scent-stations and avian point counts. We monitored post-release survival, dispersal, and habitat use using radiotelemetry. The 5-week in-surrogator survival of chicks was 78% (SE = 12) during the summer of 2009 and 79% (SE = 3) in 2010. Both mammalian and avian predator surveys revealed that the surrogator had little influence on predator populations. Eight week post-release survival of bobwhite chicks was 0.35 (SE = 0.05), which is similar to slightly lower than survival reported in previous pen-released bobwhite studies. Average home range size was 27.5 ha (SE = 8.7) with portions of all home ranges occurring off release fields. Habitat measurements at locations used by bobwhite chicks had 17% more woody cover and 16 cm taller vegetation compared to random locations. Post-release survival of surrogator bobwhites was not appreciably higher than conventionally released bobwhites, suggesting that population establishment with surrogator birds may be difficult. Further, dispersal of surrogator bobwhites off release site handicaps sportsmen's ability to establish a population of gamebirds. Given our findings, use of the surrogator may not be justifiable for all sportsmen, though some may find use for it as a tool to supplement existing populations of wild bobwhites.

Key Words: Colinus virginianus, home range, Kansas,
Corresponding Author:
Jacob Hagen, ph. (618) 980-3899, jacob.hagen@okstate.edu

INTRODUCTION

Northern bobwhite (*Colinus virginianus*; hereafter, bobwhite) populations have been and continue to decline in most portions of their range (Guthery 2000). In fact, bobwhite populations continue to decrease by about 3.8% per year in the core of their range (McKenzie 2009). Habitat loss is generally blamed for most of the population decline, though even in areas managed specifically for quail in the Southeast, populations remain lower than desirable (Evans et al. 2009). Most researchers agree that intensive farming, invasive species invasion, urban expansion, and removal of natural disturbances such as fire and grazing are some reasons for bobwhite decline (Roseberry and Klimistra 1984, Brennan 1991, Guthery 2000).

As natural bobwhite populations have dwindled, artificial propagation methods have become more prevalent as management tools. Artificial propagation is any variation of game-farming or pen-rearing of captive bobwhites for the purpose of release into the wild. The 2 primary reasons for releasing captive-reared bobwhites are restoring bobwhite populations and supplementing existing bobwhite populations to increase harvest opportunities for hunters. Numerous studies have been undertaken to evaluate the efficacy of using artificial propagation to restore bobwhite populations (Baumgartner 1944, Pierce 1951, DeVos and Speake 1995). In general, each of these studies concluded that artificial propagation of bobwhites was ineffective and unsustainable due to high costs and low survival of the birds. Stocking bobwhites for supplemental harvest has also been described as problematic due to pen-reared bobwhites appearing to lack the attributes (e.g., strong flight, elusive behavior, wild flushes) of wild birds (Hurst et al. 1993, Kozicky 1993).

One of the reasons cited as a criticism of releasing bobwhites prior to the hunting season is the low survival of the birds before the season begins. Survival of captive-reared bobwhites varies from locale and time. Evans et al. (2009) reported a 183-day survival rate of 21% for captive-reared bobwhites in Tennessee. In Alabama, DeVos and Speake (1995) reported pen-liberated bobwhite survival of 18% for 22 weeks from autumn to spring. Other fall to spring survival rates for game farm bobwhites ranged from 0–15% (Pierce 1951, Roseberry et al. 1987, Fies et al. 2000). Wild bobwhite survival has been reported to range from 39–45% from fall to spring (DeVos and Speake 1995, Guthery et al. 2004, Evans et al. 2009).

Additionally, some studies have observed predators focusing on release sites to prey on these naïve birds (Sisson et al. 2000, Oakley et al. 2002), which may result in captive-reared birds being more vulnerable to predation than wild birds. DeVos and Speake (1995) showed that compared to mortality of a natural population, pen-raised bobwhites were more susceptible to mammalian predation. Due to the high mortality in pen-released birds, sportsmen continue to seek a captive-release technique that produces bobwhites that are less vulnerable to predation and survive to provide recreation for the hunter.

To avoid the low survival of captive-released bobwhites and to recoup their economic investment in the birds, sportsmen may release pen-raised bobwhites hours or minutes prior to a hunt. This type of release can be successful as birds tend to remain close to the release site, and initial survival is high resulting in hunters being able to bag higher numbers of bobwhites (Berger 1977). However, this release technique still has the issue of captive-reared bobwhites not having comparable attributes to wild bobwhites.

The surrogator method of gamebird propagation was developed over a decade ago to alleviate problems such as poor flight, low survival, and erratic dispersal that are normally associated with captive releases of gamebirds. The surrogator is an in-field captive-rearing system that claims to imprint gamebirds, including bobwhites, to the field on which they are released. By placing the surrogator in the field where the birds will be released, this system claims to foster fidelity to that field and eliminate erratic dispersal normally associated with conventional pen releases. The surrogator contains a feeder, waterer, heater, and release door. One-day old bobwhite chicks are placed inside the unit and human contact is limited to prevent habituation. Habituation is one of the primary complaints that sportsmen have with conventional released captive bobwhites. After 5 weeks, the release door is opened and the bobwhites leave freely.

The primary objectives of the study were:

1. Monitor in-surrogator survival of bobwhite chicks.
2. Monitor post-release survival, dispersal, and habitat use.
3. Record mammalian and raptor indices to monitor surrogator influence on predator communities.

METHODS

Study Area

This study was conducted on pastureland and land enrolled in the Conservation Reserve Program (CRP) in Kiowa County near Greensburg, Kansas. The physiography of the area is defined by gently rolling sandy plains with elevations between 400 and 800 m (U.S. Environmental Protection Agency 2007). Mean precipitation for the region is 50–66 cm with most of the precipitation occurring in the summer. Temperatures range from -7 to 7° C in January to 20 to 36° C in July (U.S. Environmental Protection Agency 2007). The area is characterized by cattle pastures, dryland crops such as wheat and milo, center pivot-irrigated crops such as corn and soybeans, and CRP fields. The CRP fields on which the research was conducted were planted in the late 1980's under the CP-2 program (Jason Johnson, Wildlife Management Technologies, personal communication). The CP-2 program is a native warm season grass mixture that includes Indian grass (*Sorghastrum nutans*), little bluestem (*Schizachyrium scoparium*), big bluestem (*Andropogon gerardii*), switchgrass (*Panicum virgatum*), sand love grass (*Eragrostis trichoides*), and side oats grama (*Bouteloua curtipendula*) (Ray Colglazier, Natural Resources Conservation Service, personal communication). Similar plant communities were found on the pastureland site. In 2009, management of CRP fields included food plots and mowing. All habitat management was discontinued in 2010 due to noncompliance with CRP guidelines. No habitat management occurred on the pastureland during the study. Study fields ranged in size from 64 to 160 ha. Surrogators were employed on 2 release fields during 2009. In 2010, the surrogator release fields from the previous year were switched to control fields, and the previous control field became a surrogator fields. I added another surrogator-release field in 2010 that had not been a control field the previous year.

Description of the Surrogator

The surrogator is a self-contained brooding and rearing facility that is composed of a heating system, feeding trough, watering system, and divider door (Fig. 1). The heating system uses LP gas and a ceramic disk to provide and distribute heat to the chicks. The feeding trough, watering system, and heater are located in the brooder of the surrogator. For the first week in the unit, chicks are confined to the brooder, which enables them to gain access to resources. The watering system consists of a water barrel from which water flows into a nippled pipe that releases droplets of water when tapped by chicks. The feeding trough has an extended lip at the bottom where game bird starter feed is gravity dispensed. After chicks have acclimated to the surrogator for a week, the divider is raised, which allows the chicks access to the loafing end of the surrogator. The surrogator is meant to be placed in the habitat in which the landowner desires the birds to eventually reside after being released.

Study Setup

Surrogators were used on 2 research fields with 2 release sites per field. In 2009, chicks were released in mid-August and late September. Throughout 2009, there were 6 total releases. In 2010, 2 groups of chicks were released in mid-June and early September. Two groups of chicks were also to be released in late July, but an equipment malfunction delayed the release of 1 group till early August. Throughout 2010, there were 6 total releases. The surrogator was prepared as per the instruction of the Wildlife Management Technologies 2009 Surrogator System Guide (Anonymous 2008). We placed approximately 125 1-day-old bobwhite chicks (Birds of Brilliance Gamebird Farm, Millford, KS) in each surrogator for each release period. Chicks were immediately counted and placed in the surrogator upon arrival and fed WMT Chick Starter Feed. Each surrogator was checked once per week during the 5-week rearing period to monitor chick survival, food and water use, temperature regulation, and chick appearance. Prior to release, the remaining chicks were banded with number 7 aluminum leg bands (National Band and Tag Co., Newport, KY) and released.

Transmitters and Telemetry

In 2010, we radio-marked approximately 10 chicks (n = 59 total) from each surrogator (BD-2 transmitter; Holohil Systems, Carp, Ontario, Canada) with 1.5-g transmitters that had a battery life of 8 weeks. We attached transmitters using a suturing technique that allowed for attachment to each chick's back (Burkepile et al. 2002). A needle was used to make 2 anterior and 2 posterior incisions through which a monofilament suture was threaded. The suture was then tied to the transmitter, and the knots glued to ensure stability (Burkepile et al. 2002). This technique was approved by the Oklahoma State University Institutional Animal Care and Use Committee (Protocol #AG-09-9).

We monitored chicks at least 3 days per week, varying the time of day to take into consideration differences in temporal movements. We used a homing technique to approach within 30 m of each chick (White and Garrott 1990). We recorded the nearest location to the chick with a GPS and recorded a compass bearing toward the direction of the chick. To minimize disturbance of chicks, we returned later and recorded the actual location. If a transmitter signal had been located in the same area multiple days, we attempted to visually locate the chick to determine its fate. If a dead bird was found, we categorized the cause of mortality as avian predation, mammalian predation, or unknown. If the skeleton was intact with only soft tissue removed, mortality was attributed to avian predation, whereas if the carcass was found with crushed bones, teeth marks on the transmitter and mammalian predator tracks nearby, mortality was attributed to mammalian predation (Curtis et al. 1988). A carcass that did not distinctly show mammalian or avian predation signs was attributed to an unknown mortality category.

We used Kaplan-Meier staggered entry procedure to generate survival curves for bobwhite chicks during the 8-week post release period (Kaplan and Meier 1958, Pollock et al. 1989). This method allows censoring of birds that were lost or suffered transmitter detachment. Because of the short life of our transmitter battery, we did not include a conditioning period to allow chicks to become accustomed to the transmitter. This may have caused us to overestimate mortality. We present survival from each surrogator release, as well as overall survival combined from all releases.

We created 100% minimum convex polygons (MCP) using the home range estimator in Hawth's tools of ArcGIS 9.2 (Mohr 1947, Beyer 2004, ArcGIS 2007, Martin et al. 2009). Because the battery life of our transmitters was a maximum of 8 weeks and we only tracked the birds 3 times per week, we were not able to produce a home range for each bird with sufficient number of locations (>20) to produce an accurate home range (White and Garrott 1990). Thus, we combined all locations from transmittered birds released per surrogator release to produce a home range for each surrogator release group. We created an additive MCP for 10-day intervals post-release. For example, the 30 day post-release MCP contained new locations from days 21-30 and also previous locations from days 1-10 and 11-20. We recorded mean distance traveled between tracking periods. We also recorded mean distance between tracking period location and surrogator release site.

Vegetation Sampling

At each habitat-use location, we collected data on several vegetation parameters. Percentage canopy coverage of shrubs was assessed using the line intercept technique (Canfield 1941). From each telemetry location, we recorded woody cover along a 4-m tape from the 4 cardinal directions. A Robel pole was used to determine visual obscurity by placing the 3-cm diameter, 150-cm tall pole perpendicular to the ground and observing visual obstruction from 4 m away and at 1 m height in the 4 cardinal directions (Robel et al. 1970). A 20 × 50 cm Daubenmire frame was used to determine the percent of herbaceous cover at each telemetry location (Daubenmire 1959). The frame was placed in the 4 cardinal directions from the location, and we estimated the percent cover for bare ground, litter, grass, and forbs. A cone of vulnerability (Kopp et al. 1998) was used to determine the susceptibility of a bobwhite to an avian attack. Using a clinometer affixed to a pole, we placed the pole perpendicular at the telemetry location and moved the pole in 8 compass directions (north, north-east, east, south-east, south, south-west, west, and north-west) recording the angle when the pole touched vegetation at each direction (Kopp et al. 1998). We also collected vegetation measurements from random points within 100 m of the telemetry location to assess habitat selection. Random points were determined using a random number generator (random.org). Means from vegetation measurements at chick locations were compared with corresponding measurements from random locations. Non-overlapping 83% confidence intervals were used to determine which habitats surrogator bobwhites selected. The 83% confidence interval was used because it has been shown that when the standard errors of the mean are approximately equal for experiments with large sample sizes, this interval will give an approximate $\alpha = 0.05$ test (Payton et al. 2003).

Scent Stations

Scent stations were used to obtain an index of mammalian predators near surrogator release fields and control fields (Leberg et al. 1983). Stations were comprised of a 1-m-diameter circle of raked soil which was wetted with approximately 11 L of water. A fatty acid scent tablet (Pocatello Supply Depot, Pocatello, ID) was then placed in the center of the circle. Stations were implemented at a rate of 1 per 26 ha, and these stations were placed about 30 m from the shoulder of county roads (Liz Forbes, Missouri Department of Conservation, personal communication). The stations were prepared at dusk and checked in the morning to determine visitation. We operated the stations once while the chicks were inside the surrogator and once after they were released. The survey was not attempted if precipitation occurred. We used a key (Mammal Tracks, Missouri Department of Natural Resources, Jefferson City, MO) to identify tracks on site. Indices of abundance on surrogator fields were then compared to control fields. Overlapping 95% confidence intervals of the means indicated similarity in indices between fields. In 2009, we were unable to obtain identifiable tracks at our scent stations due to a poor substrate for retaining tracks. In 2010, we changed the substrate to a soil with more silt and loam that retained tracks more readily.

Avian Predator Survey

We conducted surveys of avian predators by using techniques similar to the Breeding Bird Survey (Peterjohn et al. 1997). Beginning in May and continuing until October, we surveyed the treatment and control fields to determine raptor presence and relative abundance. During each survey, we stopped every 400 m along the road and recorded all avian predators seen for 3 minutes before moving on to the next stop. Surveys were conducted twice per week during the morning and evening unless precipitation or inclement weather occurred. Avian predator presence in surrogator fields was then compared to control fields. Overlapping 95% confidence intervals of the means indicated similarity in indices between fields (Payton et al. 2003).

Invertebrate Sampling

To assess food availability, we randomly collected invertebrates from control and surrogator release fields using a 38-cm-diameter sweep net at a rate of 100 sweeps (1 sweep consists of 1 movement to the side) per 32 ha in 2009 and 50 sweeps per 32 ha in 2010 (Randel et al. 2006). Invertebrates were immediately placed in a plastic bag, labeled, and frozen. We identified invertebrates to order (Eaton and Kaufman 2007) and then dried them for 24 hours at 70° C and weighed them to determine mass. We calculated mean biomass by field and used that data to construct 95% confidence intervals of the means. Overlapping 95% confidence intervals of the means indicated similarity in invertebrate biomass between fields (Payton et al. 2003).

Spring Whistle Counts

Spring whistle counts (n = 30) were used to obtain a call count index from both surrogator release and control fields. The counts began 15 June and ended 6 July during each year. Our listening posts had a radius of 400-m (Rosene 1969, Roseberry 1982). We arrived at a listening post a few minutes prior to sunrise and began listening at sunrise for 5 minutes, recording number and location of males heard and calls per male (Guthery 1986, Hansen and Guthery 2001). After 5 minutes, we moved to the next station and repeated the protocol until 1 hour after sunrise. The listening posts were located around the periphery of each research field, at a density of approximately 4 posts per 64 ha. We did not conduct counts during high winds (> 19 kph) or precipitation (Hansen and Guthery 2001).

Fall Covey Counts

Fall abundance estimates, using covey-call ("koi-lee") surveys (n = 18), occurred from 1 October through 14 November (Guthery 1986, Smith et al. 2006, Rusk et al. 2009). Listening posts had a 400 m radius (Rosene 1969, Roseberry 1982). We arrived at the post 45 minutes before sunrise and recorded location and number of coveys heard (Guthery 1986). The survey began once the first covey call was heard and ended 20 minutes later (Guthery 1986). The listening posts were located around the periphery of each research field at a density of 3 posts per 64 ha.

RESULTS

Surrogator Chick Survival

Mean in-surrogator chick survival during the 2009 field season (July-September) was 78% (SE = 12). Six groups of chicks were raised in the surrogators in 2009 with survival rates ranging from 21 to 94% (Table 1). The low 21% survival was due to a combination of mechanical failure and operator unfamiliarity with the unit. During the 2010 field season (May-September), mean in-surrogator chick survival was 79% (SE = 3) and survival rates ranged from 68 to 90% (Table 1). Some of the known causes of death inside the surrogator included entanglement in wire flooring and cannibalism. In both years, higher in-surrogator chick survival was generally recorded earlier in the summer (June and July) and declined as the season progressed (August and September) (Table 1).

In 2009, we were unable to successfully attach transmitters to chicks so survival data are only presented for 2010. Overall, the pooled 8-week Kaplan-Meier survival for chicks was 0.35 ± 0.05 (SE) (Fig. 2). The survival rates between the 2 treatment fields were quite different. Chick survival in field 3 was 0.27 ± 0.13 (SE) (Range: 0.00–0.44), while chick survival in field 17 was 0.53 ± 0.12 (SE) (Range: 0.3–0.7). Though there was a slight decrease in survival by release over the summer, overlapping 95% confidence intervals suggest that all releases had statistically similar survival rates (release 1: 0.58, 95% CI = 0.35-0.79; release 2: 0.34, 95% CI = 0.18-0.54; release 3: 0.29, 95% CI = 0.08-0.64) (Fig. 3). Overall bobwhite mortality was 49% and deaths were attributed to avian predators (27%), mammalian predators (33%), and unknown (40%).

Dispersal and Home Range

Mean dispersal distance between tracking periods for all surrogator bobwhites was 154 m ± 11.4 (SE). Bobwhites released in field 3 tended to disperse less between tracking periods (123 m ± 12) than those in field 17 (162 m ± 17) (Fig. 4 and 5). The mid-June and late July, early August releases had similar dispersal distances between tracking periods (137 m ± 12 and 133 m ± 26), while the September release had greater dispersal (175 m ± 26). Mean dispersal distance between release site and daily location for all releases was 235 m ± 11. Bobwhites in field 17 tended to be dispersed farther from their release site (267 m ± 14) than birds in field 3 (187 m ± 15). No trend appeared between release date and dispersal from surrogator (release 1: 216 m ± 11, release 2: 174 m ± 20, release 3: 338 m ± 29). Of 354 total locations, 59% were from within the release field and 41% were from off the release field. Of 231 locations taken from field 17, 73%

were from within the release field and 27% were from off the release field. Of 123 locations taken from field 3, 33% were from within the release field and 67% were from off the release field.

Pooled home range size for all fields and release dates was 27.5 ha $\pm$ 8.7. The home range for surrogator bobwhites on field 3 was 19% the size of the home range for birds on field 17, though this discrepancy may have been a function of our inability to track some of the field 3 bobwhites that dispersed into a soybean field (Table 2 and Figs. 4 and 5). Over time all home ranges increased, with the greatest amount of area being added in the 20–30 day interval post-release. Because of varying sample sizes per tracking interval, we were not able to draw conclusions on how release date affected home range size.

Vegetation Sampling

All confidence intervals had 83% intervals that did not overlap (Table 3). Greater effect sizes within line intercept and Robel visual obstruction metrics revealed surrogator bobwhites strongly selected for more tall dense woody cover compared to random sites. Surrogator bobwhites selected habitat that was 16 cm taller and 17% more woody than random sites. Bobwhites selected habitats that contained slightly more litter and forbs and a greater angle of obstruction compared to random sites (Table 3). The amount of bare ground and grass at sites also affected bobwhite use of habitat. Sites used by bobwhites contained about 6% less bare ground and grass compared to random sites (Table 3).

Predator Surveys

Mammalian abundance in surrogator fields was identical to control fields with both fields registering 0.06 ± 0.03 (SE) (95% CI = -0.01–0.13 for both) mesocarnivore visits per station. On control fields, long-tailed weasels (*Mustela frenata*) comprised 67% of the visitations, while coyotes (*Canis latrans*) comprised 33% of the visitations. On surrogator fields, raccoons (*Procyon lotor*), coyotes, and long-tailed weasels all had equal rates of visitation (33%) at scent post stations. Given these findings, it appears the surrogator did not influence mammalian abundances.

Avian predator surveys for 2009 revealed surrogator fields had 0.19 ± 0.02 (95% CI = 0.10 – 0.28) avian predators per stop and control fields had 0.08 ± 0.03 (95% CI = -0.05 –0.21) avian predators per stop. On surrogator fields, red-tailed hawks (*Buteo jamaicensis*) comprised the majority of counts (51%) followed by Swainson's hawks (*Buteo swainsoni*) (26%), unknown raptors (11%), ferruginous hawks (*Buteo regalis*) (4%), Cooper's hawks (*Accipiter cooperii*) (4%), and great-horned owl (*Bubo virginianus*) (4%). On control fields, Swainson's hawks represented 67% of the counts followed by red-tailed hawks (25%) and unknown raptors (8%). In 2010, surrogator fields had 0.13 ± 0.02 (95% CI = 0.09–0.17) avian predators per stop and control fields had 0.20 ± 0.01 (95% CI = 0.17–0.23) avian predators per stop. On surrogator-release fields, red-tailed hawks comprised 73% of the observations followed by Swainson's hawks (19%) and unknown raptors (8%). On control fields, red-tailed hawks represented the most observations (59%) followed by unidentified raptors (19%), Swainson's hawks (15%), Cooper's hawks (3%), and sharp-shinned hawks (*Accipiter striatus*) (2%). Given these findings (overlapping 95% confidence intervals), it appears avian predator abundances were not influenced by the surrogator and were similar within fields between years and between treatment and control fields.

Invertebrate Sampling

In 2009, mean monthly invertebrate biomass per sample on the control field was 0.4 g (SE=0.1; 95% CI= 0.03–0.70) and 1.8 grams (SE=0.6; 95% CI= 0.3–3.3) on surrogator fields. Overlapping 95% confidence intervals suggest no statistical difference between the means, though in this case the overlap is slight suggesting weak similarity of the means. Orders with highest biomass were Orthoptera, Coleoptera, and Hemiptera. All of these orders have been documented as important bobwhite invertebrate foods (Guthery 2000, Smith and Burger 2005). In general, mean invertebrate biomass peaked in July and decreased measurably thereafter for both control and surrogator fields (Fig. 5). In 2010, mean monthly biomass on the control fields was 2.8 g (SE = 0.8; 95% CI = 0.6 – 5.1) and 2.1 g (SE = 0.5; 95% CI =0.6 – 3.6) on surrogator fields. Overlapping 95% confidence intervals suggested no difference between the means. Orders with highest biomass were Orthoptera, Coleoptera, and Hemiptera. Peak mean invertebrate biomass occurred in September on control fields and August on surrogator fields (Fig. 5).

Call Counts

Spring "bobwhite" whistle counts in 2009 were higher near surrogator fields (4.4 $\pm$ 0.2 calling males per stop) than control fields (2.6 $\pm$ 0.4 calling males per stop). On the control field, mean calling peaked at 3.5 calling males per stop during the second week of the survey. On surrogator fields, mean calling peaked the last week of the survey at 4.9 calling males per stop. In 2010, we surveyed bobwhites during the same period as the previous year and found similar results within fields. Control fields had greater counts

(3.7 ± 0.4 calling males per stop) than the surrogator field (2.8 ± 0.2 calling males per stop). On the surrogator field, mean calling peaked at 3 calling males per stop during the second and third week of the survey. On the control field, peak calling occurred during the last week of the survey at 4.1 calling males per stop (Fig. 6).

In 2009, covey "koi-lee" surveys revealed that control fields had a higher mean number of coveys (3.9 ± 0.4 calling coveys per stop) than surrogator fields (3.3 ± 0.3 calling coveys per stop). In 2010, control fields again had a higher mean number of coveys (3.9 ± 0.6 calling coveys per stop) than surrogator fields (3.2 ± 1.1 calling coveys per stop) (Fig. 7).

DISCUSSION

Surrogator chick survival

Our 5-week in-surrogator survival estimate of approximately 79% for both years is considerably higher than the 39-day survival estimate of 37% for wild bobwhite chicks reported by DeMaso et al. (1997). Overcoming high mortality associated with wild bobwhites during the brood-rearing stage is one benefit the surrogator claims that enable it to establish a huntable population of bobwhites. Given our findings, the surrogator did have improved chick survival compared to a wild population and enabled more birds to be in the population at 5-weeks of age. In-surrogator survival of bobwhites was generally higher earlier in the summer and declined as the season progressed in both years. By operating the surrogator earlier in the summer (May-July), sportsmen may be able to maximize the number of bobwhites released, and avoid higher mortality associated with late (August-October) releases.

Our 8 week combined survival estimate of 0.35 is comparable to 8 week survival estimates of 0.40-0.45 for pen-raised birds reported by Devos and Speake (1995), Oakley et al. (2002) and Eggert et al. (2009). There was a non significant, but slight decline in survival over the summer, which may have been influenced by climatic conditions, as early months (June and July) had more rainfall (32.6 cm) than later months (August and September) (5.3 cm) (National Oceanic and Atmospheric Administration 2010), and precipitation has been reported to be an important component of bobwhite survival and reproductive success (Jackson 1962, Guthery 2000). Our release with the highest survival (June) also coincided with the peak brood-rearing period in the Southern Great Plains (Guthery 2000). Generally wild bobwhites attempt to raise broods during periods with moderate temperatures, ample rainfall, and abundances of invertebrates (Stoddard 1931, Guthery 2000), and these reasons could be why survival of surrogator bobwhites were higher in this period.

Our results call into question the surrogator's ability to establish a huntable population of bobwhites, given such low survival. Other researchers have found similar to slightly higher survival rates of pen-released bobwhites and concluded that population establishment with pen-reared birds was futile (Roseberry et al. 1987, DeVos and Speake 1995). Annual survival of self-sustaining populations of wild bobwhites are about 20% (Guthery 2000). Given low surrogator bobwhite survival (35%) at only 8 weeks, it would be difficult to sustain a population with that rate of survival into perpetuity. Further, during the 2009–2011 bobwhite hunting season; surrogator bobwhites supplemented harvest of wild bobwhites by 31%, but establishment of a huntable population of strictly surrogator bobwhites within the release field by the hunting season did not occur (J. M. Hagen, unpublished data).

Some researchers question whether transmitter attachment handicaps species and causes low survival estimates (Guthery and Lusk 2004). Other researchers concluded that transmitter attachment does not influence survival (Mueller et al. 1988). If handicapping did occur, our survival estimate would have been biased low, and our reported survival would have been a conservative estimate. Our radiotelemetry results should be interpreted with caution, as we had no way of knowing whether radio-transmitter handicapping occurred.

Due to poor performance, we changed our banding and transmitter attachment techniques between 2009 and 2010. In 2009, we used a combination of plastic spiral leg bands and metal butt-end bands. After determining that the metal bands did not harm the birds, we used them exclusively in 2010. In 2009, we attempted to attach transmitters using various gluing methods, none of which were successful. In 2010, we switched transmitter attachment methods and used a suturing technique (Burkepile et al. 2002). Retainment of transmitters was excellent, though about 5% did detach (suture thread apparently coming undone or breaking).

Generally, avian predators are a significant threat to bobwhites and cause the majority of deaths (Sisson et al. 2000). For pen-liberated bobwhites, avian predators have been reported to cause about 60% of deaths, mammalian predators 30%, and other sources 10% (DeVos and Speake 1995, Eggert et al. 2009). Mortalities of wild bobwhites show a similar composition, with raptors causing roughly 55% of deaths, mammalian predators 25%, and other sources 20% (Guthery et al. 2004, Sisson et al.

2009). We found similar rates of predation due to mammalian predators (33%), though our avian predation rate (27%) and rate of unknown predators (40%) were dissimilar to previous estimates. Our ability to attribute mortality to a specific cause was hindered by a number of factors; thus, we had to place many deaths into the unknown mortality category. Unlike some transmitters, ours did not have mortality sensors and thus, we were not able to quickly determine if a transmitter was immobile. By only tracking 3 days per week, the likelihood of a scavenger tampering with a deceased bird or transmitter was increased in the interim, which could have biased our estimate in favor of mammalian scavenging (Bumann and Stauffer 2002). In areas where transmittered birds had dispersed into standing crops, we were unable to access the field until the crop was harvested and then, only briefly. For birds that died in the crop field, it was difficult to determine what caused the death because it was so long after the mortality occurred, which resulted in most being categorized into unknown predation. The maximum range of our transmitters was about 0.7 km which also hampered our ability to quickly recover a bird that had moved or had been moved far away.

Dispersal and Home Range

Liu et al. (2009) reported an average daily dispersal rate of 189 m for bobwhites in Texas. Our pooled mean dispersal distance between tracking periods was slightly less (154 m). The tracking period with greatest between tracking dispersal distance was the final release. This is possibly because suitable habitats nearby may have been occupied by previously released birds or wild bobwhites, forcing them to disperse further in search of unoccupied areas (Townsend et al. 2003). Our pooled mean between-tracking dispersal distance from release site was 235 m. Our release fields were both 64 ha, and the percentage of locations taken within the release site (59%) was slightly greater than location taken offsite (41%). These data indicate that unless the surrogator owner possesses a substantial amount of land, nearly half of released bobwhites may disperse offsite.

Our home range estimate per surrogator may be most comparable to bobwhite brood studies, as both home range areas represent the home range of multiple birds. Martin et al. (2009) monitored wild bobwhite broods till 14 days post-hatching and reported mean brood home range of 5.5 ha $\pm$ 2.4. Another brood home range study reported an area of 13 ha $\pm$ 2 after tracking the hen and brood for 21 days post-hatch (Talyor et al. 1999b). These estimates are not directly comparable to ours, as surrogator bobwhites were 5 weeks of age when released and not associated with a hen. The influence of not having an adult bobwhite to lead surrogator chicks is unknown, but is of interest and deserves further research.

All of our MCP's included some to nearly all of their area off release property indicating low fidelity to release field. All of the home ranges increased in size over time, indicating that bobwhite movements were not constrained to a core area of use. Fies et al. (2002) reported that juvenile bobwhites disperse further than adults possibly to colonize unsettled areas. Dispersal and home range size of bobwhites vary widely and is largely dependent on habitat composition and existing predator and prey populations (Fies et al. 2002). Eggert et al. (2009) reported an average home range of 28.4 ha after following pen-liberated bobwhites from March through September. Oakley et al. (2002) reported an average pen-released bobwhite home range of 36 ha after following 103 radio-marked quail for 228 days. Other home range studies for wild bobwhites report home ranges of 4.2 to 36.6 ha (Wiseman and Lewis 1981, Bell et al. 1985, Dixon et al. 1996, Mueller et al. 1997). Our pooled mean home range estimate of 27.5 ha is remarkably similar to the previous estimates of both game farm and wild bobwhites, suggesting that surrogator bobwhites are comparable to other pen-reared and wild bobwhites in this category.

Unforeseen issues may have complicated our results on some of the research properties. In 2010, some of the research fields were out of compliance with CRP guidelines and all woody species were killed with herbicide. Bobwhite use of tall leafy coverts as a refuge from predators and heat has been widely reported (Stoddard 1931, Rosene 1969, Johnson and Guthery 1988). As most of the foliage of coverts on our herbicide treated sites would have been eliminated, this may have led bobwhites to search off-property for adequate summer loafing areas as evidenced by the percent of locations on (33%) and off (67%) the release field. In 2009, we had placed the surrogator units throughout the interior of the field, while in 2010, we were unable to drive into the interior of the CRP field because of recently enforced regulations, resulting in the surrogator units being setup along the perimeter of the field for ease of access. The impact of this change is unknown, but dispersal may have been influenced by the shift in release site being closer to the field boundary.

Habitat metrics

Much has been written about the necessity of protective coverts for bobwhites (Stoddard 1931, Rosene 1969, Guthery 2000). Our habitat measurements supported this and revealed greater and denser shrub cover at used locations compared to random points. These 2 habitat measurements especially corroborate Johnson and Guthery (1988) who reported that bobwhites select tall leafy coverts as a refuge from heat in the summer. Bobwhites that fly or move about during the heat of the day, especially in arid areas, are susceptible to heat stress and death (Guthery 2000). Therefore, bobwhites must remain in the shade of tall brushy cover in order to regulate their body temperature (Guthery 2000). Releases of our surrogator bobwhites were all conducted in the summer and it is probable that they selected tall dense cover for similar reasons as stated above. Surrogator bobwhites selected habitat that appear to have features that possibly made the birds less vulnerable to avian predators compared to random locations. Wild bobwhites have also been reported to select habitat which makes them less vulnerable to avian predators (Kopp et al. 1998). Kopp et al. (1998) reported that compared to random locations, wild bobwhites selected slightly less bare ground, and these findings are similar to our results. Surrogator bobwhite locations had greater litter compared to random locations. This may be because litter accumulated under shrub cover more than random locations (J.M. Hagen, personal observation). Wild bobwhites have been reported to select for habitats with more forbs and less grass, which is similar to our results (Taylor et al. 1999a). It appears surrogator bobwhites generally selected for habitats similar to wild bobwhites.

A critical assumption of our habitat measurements was that we were able to accurately estimate the direction and distance from observer location to the transmittered chick. In our attempt to not influence or disturb transmittered birds, we made all efforts to not approach past 20–30 m. Our ability to precisely gauge how far and what direction the chick was from our location is unknown, but any error in estimation may have led us to sample vegetation at micro-sites where the bird actually was not, possibly producing skewed results. This could have been particularly influential in small scale habitat measurement metrics (Daubenmire frame and cone of vulnerability), where even a slight change in the site could produce very different results.

Predator Surveys

Our mesocarnivore surveys revealed no difference in indices between surrogator-release fields and control fields. These findings are similar to Hutchins and Hernandez (2003) who reported no significant difference between mammalian surveys on captive-released quail fields and control fields. Our raptor surveys revealed little change in mean indices between control and surrogator fields (overlapping 95% CI) for both years with and without the surrogator, suggesting that surrogators had little influence on existing raptor populations. The composition of our surveys were dominated by secondary predators of bobwhites (red-tailed hawk and Swainson's hawk), while primary predators (*Accipiter* spp., northern harriers (*Circus cyaneus*), and great-horned owls) comprised few observations (Rollins and Carroll 2001). While personal observation and motion-detection cameras placed near surrogator units showed both mesocarnivores and avian predators visited the surrogator, our surveys showed that predators also visited control fields at similar rates. An important assumption of our predator survey methodology was that the control fields and surrogator fields were similar in habitat. Any difference in habitat may have caused higher or lower predator indices and biased our findings.

Invertebrate Sampling

In 2010, mean biomass of invertebrates per month was highest on surrogator field 17, while field 3 had far lower invertebrate biomass. Low biomass of invertebrates within field 3 may have been a reason why bobwhites dispersed offsite, though around 5–10 weeks of age the primary food sources of bobwhite chicks shift from invertebrates to succulent grasses and seeds, thus, it is difficult to explain precisely why field 3 bobwhites dispersed offsite (Rosene 1969, Guthery 2000). Interestingly, our invertebrate samples did not respond as quickly to precipitation as other studies had shown (Anderson et al. 2009). The highest amount of rainfall on our study sites occurred in June and July, but peak invertebrate samples did not occur until August and September. The explanation for this is unclear, though surrogator bobwhite survival was not impacted by this as slightly higher survival occurred earlier in the summer (June and July).

Call Counts

Spring "bobwhite" whistle count rates revealed little change between fields or between years. Counts from control fields in 2010 (previous surrogator fields in 2009) revealed similar rates between years, suggesting that the surrogator had no effect on the number of calling males. Data from the Kansas Department of Wildlife and Parks show that unlike most regions of Kansas, the south-central and west regions (Greensburg and our study area included) have relatively stable populations of bobwhites (Pittman 2009, 2010). High populations of wild bobwhites may have forced surrogator released bobwhites to disperse farther in search of unoccupied or marginal habitat (Fies et al. 2002, J. M. Hagen, unpublished data). Acceptance of pen-raised bobwhites into wild coveys did occur though, as we had several instances of sportsmen harvesting wild and surrogator bobwhites from the same covey (J. M. Hagen, unpublished data).

Surrogator bobwhite released in the summers of 2009 and 2010 would have been old enough to emit the covey call "koi-lee" during our surveys in the fall of 2009 and 2010 (Stoddard 1931). Fall covey call counts were not higher on surrogator release fields in 2009 or 2010 and were actually slightly higher on control fields in both years.

Surrogator bobwhites may have incurred high mortality by the time covey call counts were initiated that few were in the population to emit the call. Dispersal of surrogator bobwhites off site, also may have lessened the influence of surrogator birds on covey call counts.

MANAGEMENT IMPLICATIONS

Our findings indicate that surrogator bobwhite survival may be too low at 8 weeks to sustain enough birds for a huntable population solely of surrogator bobwhites. Populations of native bobwhites incur high annual mortality which is only offset by their tenacious reproductive efforts. Trying to mimic nature's ability to produce abundances of bobwhites is difficult given the high ratio of bobwhites that perish for every bobwhite that survives.

Surrogator bobwhite dispersal off property further hinders the ability of the surviving birds to provide recreation for sportsmen. Wild bobwhites move across various habitats and coverts oblivious to property boundaries. Acclimating bobwhites to live within a certain area is difficult as bobwhite dispersal can be lengthy and erratic and home ranges can overlap multiple properties.

Time and cost are factors that most wildlife enthusiasts must allocate wisely when considering how to manage natural resources. In most states, quality bobwhite habitat can only be maintained by costly and time intensive land management practices. Surrogator bobwhite also need to be released in intensively managed habitat in order to be given optimal chances of survival. Buying, rearing, and releasing bobwhites further compounds existing management expenses

Given our findings, the claim that the surrogator will establish a huntable population of bobwhites within a field by that hunting season was not confirmed. Establishment of a huntable population of bobwhites within the release field did not occur due to low survival and erratic dispersal. The goals of sportsmen and bobwhite enthusiasts vary widely and our results may be interpreted differently among parties. Some sportsmen may find use for the surrogator as a tool to supplement wild populations and allow higher harvest in the hunting season. Other sportsmen will not be able to justify use of the surrogator because the costs of operating the system outweigh the benefits.

Use of the surrogator to restore bobwhite populations in unoccupied habitat may also have marginal levels of success. Our research fields all had existing populations of wild bobwhites, thus, we were not able to examine this question directly and more research on this specific topic is warranted. Surrogator bobwhites were able to survive into the hunting season (J.M. Hagen, unpublished data) though their survival to the breeding season and subsequent ability to nest and raise chicks is unknown and deserves further research. Previous pen-released bobwhite studies have concluded that given low survival, restoring depleted habitats with pen-released bobwhites was ineffective, and given our similar survival, use of the surrogator to accomplish the same goal may also be ineffective.

ACKNOWLEDGMENTS

Funding and assistance for this project was provided by Wildlife Management Technologies, Frank W. Merrick Foundation Management, Game Bird Research Fund, Oklahoma State University's Department of Natural Resources Ecology and Management and the Oklahoma Cooperative Fish and Wildlife Research Unit. Technical assistance and guidance

was provided by Dwayne Elmore, Jason Johnson, Matt White, Mark Gregory, and numerous Oklahoma State graduate students.

LITERATURE CITED

Anderson, C. W., R. M. Whiting, Jr., D. R. Dietz, and R. M. Capps. 2009. Invertebrate biomass and richness in various food plot types in east Texas. Pages 66–77 *in* Cederbaum S. B., Faircloth B. C., Terhune T. M., Thompson J. J., Carroll J. P., eds. Gamebird 2006: Quail VI and Perdix XII. 31 May – 4 June 2006. Warnell School of Forestry and Natural Resources, Athens, GA, USA.

Anonymous. 2008. Wildlife management technologies 2009 surrogator system guide. Wildlife Management Technologies, Wichita, Kansas, USA.

ArcGIS [computer program]. 2007. Version 9.2. Redlands, CA: Environmental Systems Research Institute, Inc.

Baumgartner, F. M. 1944. Dispersal and survival of game farm bobwhite quail in northcentral Oklahoma. Journal of Wildlife Management 8:112–118.

Bell, B., K. Dancak, and P. J. Zwank. 1985. Range, movements, and habitat use by bobwhites in southeastern Louisiana pinelands. Proceedings of the Annual Conference of Southeastern Association of Fish and Wildlife Agencies 39: 512–519.

Berger, A. J. 1977. Fitness of offspring from captive populations. Pages 315–320 *in* S. A. Temple, editor. Endangered birds: management techniques for preserving threatened species. University of Wisconsin, Madison, USA.

Beyer, H. L. 2004. Hawth's tools analysis for ArcGIS. Available at http://www.spatialecology.com/htools.

Bumann, G. B. and D. F. Stauffer. 2002. Scavenging of ruffed grouse in the Appalachians: influences and implications. Wildlife Society Bulletin 30: 853–860.

Brennan, L. A. 1991. How can we reverse the northern bobwhite population decline. Wildlife Society Bulletin 19:544–555.

Burger, L. W., D. A. Miller, and R. I. Southwick. 1999. Economic impacts of northern bobwhite hunting in the southeastern U. S.. Wildlife Society Bulletin 27: 1010–1018.

Burkepile, N. A., J. W. Connelly, D. W. Stanlay, and K. P. Reese. 2002. Attachment of radiotransmitters to one-day-old sage grouse chicks. Wildlife Society Bulletin 30:93–96.

Canfield, R. H. 1941. Application of the line interception method in sampling range vegetation. Journal of Forestry 39:388–394.

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

Daubenmire, R. 1959. A canopy coverage method of vegetation analysis. Northwest Science 33:43–65.

DeMaso, S. J., A. D. Peoples, S. A. Cox, and E. S. Parry. 1997. Survival of northern bobwhite chicks in western Oklahoma. Journal of Wildlife Management 61: 846–853.

DeVos, T. and D. W. Speake. 1995. Effects of releasing pen raised northern bobwhites on survival rates of wild populations of northern bobwhites. Wildlife Society Bulletin 23:267–273.

Dixon, K. R., M. A. Horner, S. R. Anderson, W. D. Henriques, D. Durham, and R. J. Kendall. 1996. Northern bobwhite habitat use and survival on a South Carolina plantation during winter. Wildlife Society Bulletin 24:627–635.

Eaton, E. R. and K. Kaufman. 2007. Kaufman field guide to insects of North America. Hillstar Editions, New York, New York, USA.

Eggert, D. A, B. S., Mueller, L. Robinette, and S. D. Wellendorf. 2009. Comparison of survival, productivity, movements, and habitat use of pre-season released quail on wild northern bobwhites on Groton Plantation, South Carolina. Pages 396 – 408 *in* Cederbaum S. B., Faircloth B. C., Terhune T. M., Thompson J. J., Carroll J. P., eds. Gamebird 2006: Quail VI and Perdix XII. 31 May – 4 June 2006. Warnell School of Forestry and Natural Resources, Athens, GA, USA.

Evans, K. O., M. D., Smith, L. W. Burger Jr., R. J., Chambers, A. E., Houston and R. Carlisle. 2009. Release of pen-reared bobwhites: potential consequences to the genetic integrity of resident wild populations. Pages 121–133 *in* S. B. Cedarbaum, B. C. Faircloth, T. M., Thompson J. J., Carroll J. P., eds. Gamebird 2006: Quail VI and Perdix XII. 31 May – 4 June 2006. Warnell School of Forestry and Natural Resources, Athens, GA, USA

Fies, M. L., J. E. Fischer, and D. E. Steffen. 2000. Survival of game farm, F1-wild progeny, and wild relocated northern bobwhites using two release methods.

Proceedings of the Annual Conference of the Southeastern Association of Fish and Wildlife Agencies 54:350–364.

Fies, M. L., K. M. Puckett, and B. Larson-Brogdon. 2002. Breeding season movements and dispersal of northern bobwhites in fragmented habitats of Virginia. Pages 173–179 *in* S. J. DeMaso, W. P. Kuvlesky, Jr., F. Hernandez, and M. E. Berger, eds. Quail V: Proceedings of the Fifth National Quail Symposium. Texas Parks and Wildlife Department, Austin, TX, USA.

Guthery, F. S. 1986. Beef, brush, and bobwhites. Caesar Kleberg Wildlife Research Institute, Kingsville, Texas, USA.

Guthery, F. S. 2000. On bobwhites. Texas A&M University, College Station, Texas, USA.

Guthery, F. S., and J. J. Lusk. 2004. Radiotelemetry studies. are we radio-handicapping northern bobwhites. Wildlife Society Bulletin 32:194–201.

Guthery, F. S., T. L. Hiller, W. H. Puckett, Jr. R. A. Baker, S. G. Smith, and A. R. Rybak. 2004. Effects of feeders on dispersion and mortality of bobwhites. Wildlife Society Bulletin 32:1248–1254.

Hansen, H. M. and F. S. Guthery. 2001. Calling behavior of bobwhite males and the call-count index. Wildlife Society Bulletin 29:145–152.

Hurst, G. A., W. R. Davidson, T. DeVos, E. L. Kozicky and A. D. Peoples. 1993. Releases of pen-raised quail. Pages 178–179 *in* K. Church and T. Dailey, editors. Quail III: National Quail Symposium. Kansas Department of Wildlife and Parks. Pratt, Kansas, USA.

Hutchins, A. R. and F. Hernandez. 2003. Effects of pen-raised northern bobwhite introductions on wild bobwhites in south Texas. Proceedings of the Annual Conference of Southeastern Fish and Wildlife Associations 57:181–191.

Jackson, A. S. 1962. A pattern to population oscillation of the bobwhite quail in the lower plains grazing ranges of northwest Texas. Proceedings of the Annual Conference of Southeastern Fish and Wildlife Associations 16:120–126.

Johnson, D. B. and F. S. Guthery. 1988. Loafing coverts used by northern bobwhites in subtropical environments. Journal of Wildlife Management 52: 464–469.

Kaplan, E. L. and P. Meier. 1958. Nonparametric estimation from incomplete observations. Journal of the American Statistical Association. 53:457–481.

Kopp, S. D., F. S., Guthery, N. D. Forrester, and W. E. Cohen. 1998. Habitat selection for modeling northern bobwhites on subtropical rangeland. Journal of Wildlife Management 62:884–895.

Kozicky, E. L. 1993. The history of quail management with comments on pen-rearing. Pages 1–7 *in* K. E. Church and T. V. Dailey, editors. Quail III: national quail symposium. Kansas Department Wildlife and Parks, Pratt, Kansas, USA.

Leberg, P .L., M. L. Kennedy, and R. A. Van Den Bussche. 1983. Oppossum demography and scent- station visitation in western Tennessee. Proceedings of the annual conference of the southeast association of fish and wildlife agencies 37:34–40.

Liu, X., R. M. Whiting, Jr., D. S. Parsons, and D. R. Dietz. 2002. Movement patterns of resident and relocated northern bobwhites in eastern Texas. Pages 168–172 *in* S. J. DeMaso, W. P. Kuvlesky, Jr., F. Herna´ndez, and M. E. Berger, eds. Quail V: Proceedings of the Fifth National Quail Symposium. Texas Parks and Wildlife Department, Austin, TX.

Martin, N., J. A. Martin, J. P. Carroll. 2009. Northern bobwhite brood habitat selection in south Florida. Pages *88–97* in *in* S. B. Cedarbaum, B. C. Faircloth, T. M. Terhune, J. J. Thompson, J. P. Carroll, editors. Gamebird 2006: Quail VI and Perdix XII. 31 May – 4 June 2006. Warnell School of Forestry and Natural Resources, Athens, Georgia, USA.

McKenzie, D. F. 2009. Taking the northern bobwhite conservation initiative to the next level. Pages 16–23 *in* S. B. Cedarbaum, B. C. Faircloth, T. M. Terhune, J. J. Thompson, J. P. Carroll, editors. Gamebird 2006: Quail VI and Perdix XII. 31 May – 4 June 2006. Warnell School of Forestry and Natural Resources, Athens, Georgia, USA.

Mohr, C. O. 1947. Table of equivalent populations of North American small mammals. American Midland Naturalist 37:223–249.

Mueller, B. S., J. B. Atkinson, Jr., and T. DeVos. 1988. Mortality of radio-tagged and unmarked northern bobwhite quail. Biotelemetry X:139–144.

Mueller, B. S., L. Robinette, and J. Wilson. 1997. Progress report number 2: a study to determine the impacts of pen-raised bobwhites on native quail populations. Clemson University, Clemson, South Carolina.

National Oceanic and Atmospheric Administration. Climatological Report (Monthly). Accessed 7 June, 2011 <http://www.weather.gov/climate/index.php?wfo=ddc>

Oakley, M. J., D. L. Bounds, T. A. Mollett, and E. C. Soutiere. 2002. Survival and home range estimates of pen-raised northern bobwhites in buffer strip and non-buffer strip habitats. Pages 74–80 *in* S. J. DeMaso, W. P. Kuvlesky, Jr., F. Hernandez, and M. E. Berger, eds. Quail V: Proceedings of the Fifth National Quail Symposium. Texas Parks and Wildlife Department, Austin, TX, USA.

Payton, M. E., M. H. Greenstone, and N. Schenker. 2003. Overlapping confidence intervals or standard error intervals: what do they mean in terms of statistical significance. Journal of Insect Science 34:1–6.

Peterjohn, B. G., J. R. Sauer, and W. A. Link. 1997. The 1994 and 1995 summary of the North American breeding bird survey. Bird Populations 3:48–66.

Pierce, R. A. 1951. Survival of pen-reared quail. Final Rep., Pittman-Robertson Pro. W-6-R. Kentucky Division of Fish and Game. 164pp.

Pittman, J. 2009. 2009 Bobwhite whistle count: Performance report. Kansas Department of Wildlife and Parks. Pittman-Robertson Federal Aid in Wildlife Restoration Grant W-39-R-15. Pratt, Kansas, USA.

Pittman, J. 2010. 2010 Bobwhite whistle count: Performance report. Kansas Department of Wildlife and Parks. Pittman-Robertson Federal Aid in Wildlife Restoration Grant W-39-R-16. Pratt, Kansas, USA.

Pollock, K. H., S. R. Winterstein, C. M. Bunck, and P. D. Curtis. 1989. Survival analysis in radio-telemetry studies: the staggered entry design. The Journal of Wildlife Management 53:7–15.

Randel, C. J., R. B., Aguirre, M. J. Peterson, and N. J. Silvy. 2006. Comparison of two techniques for assessing invertebrate availability for wild turkeys in Texas. Wildlife Society Bulletin 34:853–855.

Robel, R. J., J. N. Briggs, A. D. Dayton, and L. C. Hulbert. 1970. Relationships between visual obstruction measurements and weight of grassland vegetation. Journal of Range Management 23:295–297.

Rollins, D., and J. P. Carroll. 2001. Impacts of predation on northern bobwhite and scaled quail. Wildlife Society Bulletin 29:39–51.

Roseberry, J. L. 1982. Bobwhite. Pages 68–70 *in* D. E. Davis, editor. Handbook of census methods for terrestrial vertebrates. CRC, Boca Raton, Florida, USA.

Roseberry, J. L. and W. D. Klimstra. 1984. Population ecology of the bobwhite . Southern Illinois University, Carbondale and Edwardsville, Illinois, USA.

Roseberry, J. L., D. L. Ellsworth, and W. D. Klimstra. 1987. Comparative post-release behavior and survival of wild, semi-wild, and game farm bobwhites. Wildlife Society Bulletin 15:449–455.

Rosene, W. 1969. The bobwhite quail: It's life and management. Rutgers University Press New Brunswick, N.J. 418pp

Rusk, J. P., J. L. Scott, F. Hernandez, and F. C. Bryant 2009. Refining the morning covey-call survey to estimate northern bobwhite abundance. Pages 38 – 45 *in* S. B. Cedarbaum, B. C. Faircloth, T. M. Terhune, J. J. Thompson, J. P. Carroll, editors. Gamebird 2006: Quail VI and Perdix XII. 31 May – 4 June 2006. Warnell School of Forestry and Natural Resources, Athens, Georgia, USA.

Sisson, D. C., D. W. Speake, and H. L. Stribling. 2000. Survival of northern bobwhites on areas with and without liberated bobwhites. Proceedings of the Fourth National Quail Symposium 4:92–94.

Sisson, D. C., T. M. Terhune, H. L. Stribling, J. F. Sholar, and S. D. Mitchell. 2009. Survival and causes of mortality for northern bobwhites in the southeastern USA. Pages 467 – 478 *in* S. B. Cedarbaum, B. C. Faircloth, T. M. Terhune, J. J. Thompson, J. P. Carroll, editors. Gamebird 2006: Quail VI and Perdix XII. 31 May – 4 June 2006. Warnell School of Forestry and Natural Resources, Athens, Georgia, USA.

Smith, M. D., and L. W. Burger, Jr. 2005. Use of imprinted northern bobwhite chicks to assess habitat-specific arthropod availability. Journal of Wildlife Management 33:596–605.

Smith, M. D., R. G. Hamrick, L. W. Burger Jr., and J. P. Carroll. 2006. Estimating sample sizes for distance sampling of autumn northern bobwhite calling coveys. Pages 46–53 *in* S. B. Cedarbaum, B. C. Faircloth, T. M. Terhune, J. J. Thompson, J. P. Carroll, editors. Gamebird 2006: Quail VI and Perdix XII. 31 May – 4 June 2006. Warnell School of Forestry and Natural Resources, Athens, Georgia, USA.

Stoddard, H. L. 1931. The bobwhite quail: its habits, preservation, and increase. Charles Scribner's Sons, New York, New York, USA.

Taylor, J. S., K. E. Church, and D. H. Rusch. 1999a. Microhabitat selection by nesting and brood-rearing northern bobwhite in Kansas. Journal of Wildlife Management 63:686–694.

Taylor, J. S., K. E. Church, D. H. Rusch, and J. R. Cary. 1999b. Macrohabitat effects on summer survival , movements, and clutch success of northern bobwhite in Kansas. Journal of Wildlife Management 63:675–685.

Townsend, D. E., D. M., Leslie, Jr., R. L. Lochmiller, S. J. DeMaso, S. A. Cox, and A. D. Peoples. 2003. Fitness costs and benefits associated with dispersal in northern bobwhites (Colinus virginianus). American Midland Naturalist 150:73–82.

U. S. Environmental Protection Agency. Western Ecology Division: Ecoregions of Kansas and Nebraska 2007. <http://www.epa.gov/wed/pages/ecoregions/ksne_eco.htm>. Accessed 30 Jan 2010.

White, G. C. and R. A. Garrott. 1990. Analysis of wildlife radiotracking data. Academic, San Diego, California, USA.

Wiseman, D. S. and J. C. Lewis. 1981. Bobwhite use of habitat in tallgrass rangeland. Wildlife Society Bulletin 9:248–255.

Tables and Figures

Table 1. In-surrogator (%) survival of Northern Bobwhite chicks in Kiowa County, Kansas during 2009 (n = 765) and 2010 (n = 783).

	Survival			
Release	2009	Date	2010	Date
1	94	11 Aug	90	15 June
2	92	11 Aug	84	15 June
3	94	11 Aug	76	28 July
4	21	27 Sept	82	10 Aug
5	81	27 Sept	73	7 Sept
6	88	27 Sept	68	7 Sept

Table 2. Home range per surrogator release for all Northern Bobwhites combined per unit in Kiowa County, Kansas, from June–October 2010.

Release site and 2010 date	Days post-release	No. of locations	Area (ha)
Field 3 6-15 (*n*=9)	10	34	6.9
	20	51	7.5
	30	81	15.7
	40	88	16.7
Field 17 6-15 (*n*=9)	10	40	11
	20	61	13.5
	30	103	28.8
	40	119	55.4
Field 3 8-1 (*n*=15)[1]	10	21	1.8
	20	25	1.8
Field 17 7-28 (*n*=9)	10	31	7.1
	20	47	14.7
	30	55	40.4
Field 3 9-7 (*n*=5)	10	12	0
	20	22	1.2
	30	29	8.9
Field 17 9-7 (*n*=4)	10	16	13.1
	20	32	23.8
	30	41	27.6
	40	50	36.5
	50	53	41.6

[1] Bobwhites from this release travelled almost immediately into a soybean field, and we did not have access to track them.

Table 3. Habitat characteristics of sites used by surrogator Northern Bobwhites and random sites (*n* = 253 paired sites) in Kiowa County, Kansas, June-October 2010.

	Used				Random				Effect Size	
Variable	$\bar{x}_1$	SE	LCI	UCI	$\bar{x}_2$	SE	LCI	UCI	$\bar{x}_1 - \bar{x}_2$	SE
Daubenmire coverage (%)										
Bare ground	3.93	0.84	3.35	4.50	10.00	0.85	9.15	10.85	-6.07	2.31
Litter	27.88	2.02	26.59	29.27	19.40	2.06	18.24	20.56	8.48	2.99
Grass	45.48	2.10	44.04	46.92	50.93	2.14	49.46	52.40	-5.45	1.92
Forb	19.05	1.44	18.06	20.04	16.52	1.47	15.61	17.42	2.53	0.89
Line intercept (%)	39.25	2.74	37.37	41.13	22.02	2.80	20.30	23.74	17.23	6.09
Robel (cm)	46.97	2.65	45.15	48.79	30.88	2.70	29.30	32.46	16.09	5.69
Angle of obstruction (°)	89.56	0.21	89.42	89.70	85.49	0.21	84.89	86.09	4.07	2.04

Figure 1. The Surrogator® XL shown on a research site in Kiowa County, Kansas, in May 2010.

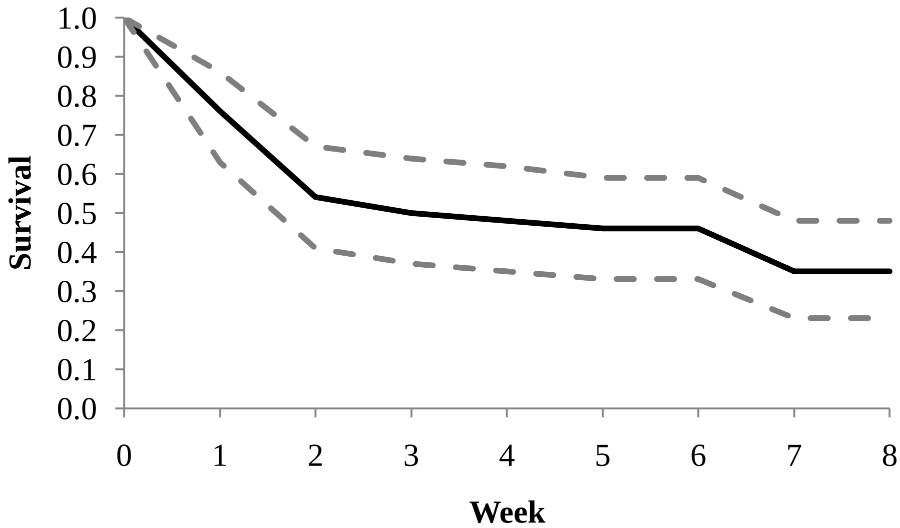

Figure 2. Kaplan-Meier survival curve with 95% CI (dashed lines) for surrogator Northern Bobwhites (*n* = 59) in Kiowa County, Kansas, from June–October 2010.

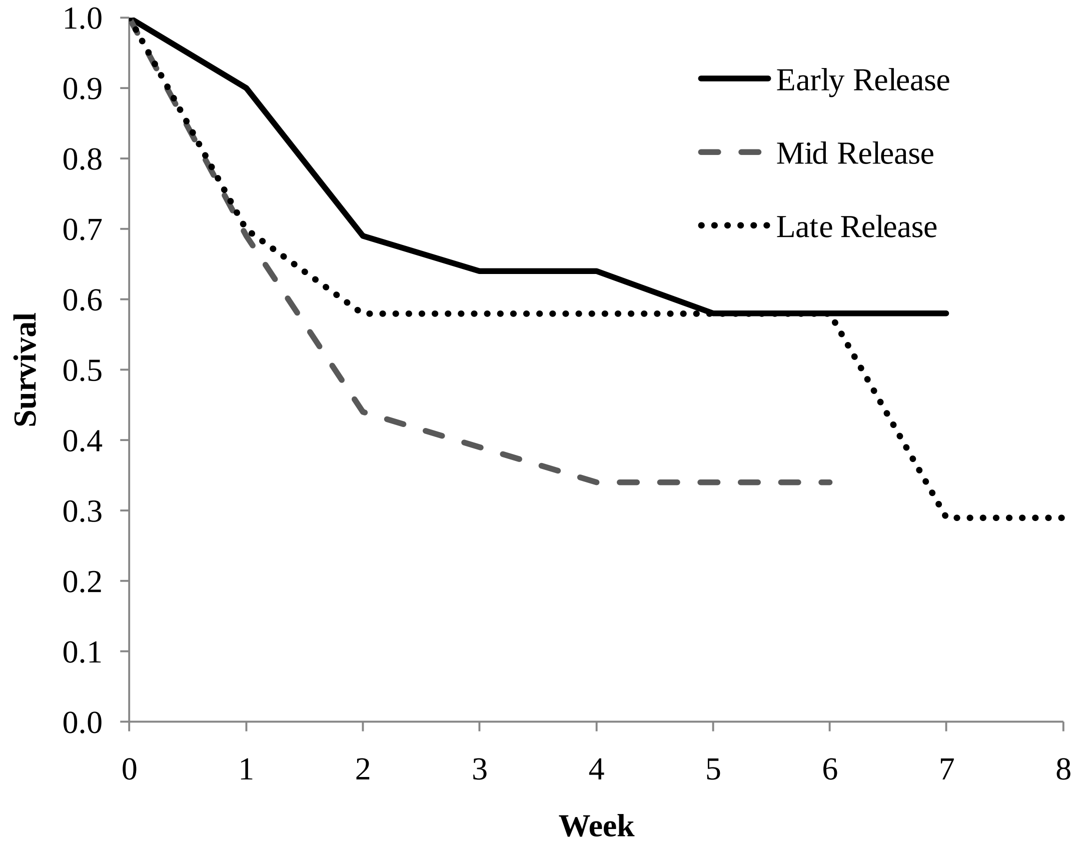

Figure 3. Kaplan-Meier survival curves of surrogator Northern Bobwhites for early release (15 June) (*n* = 20), mid release (28 July and 10 August) (*n* = 29) and late release (7 September) (*n*=10) in Kiowa County, Kansas, June-October 2010.

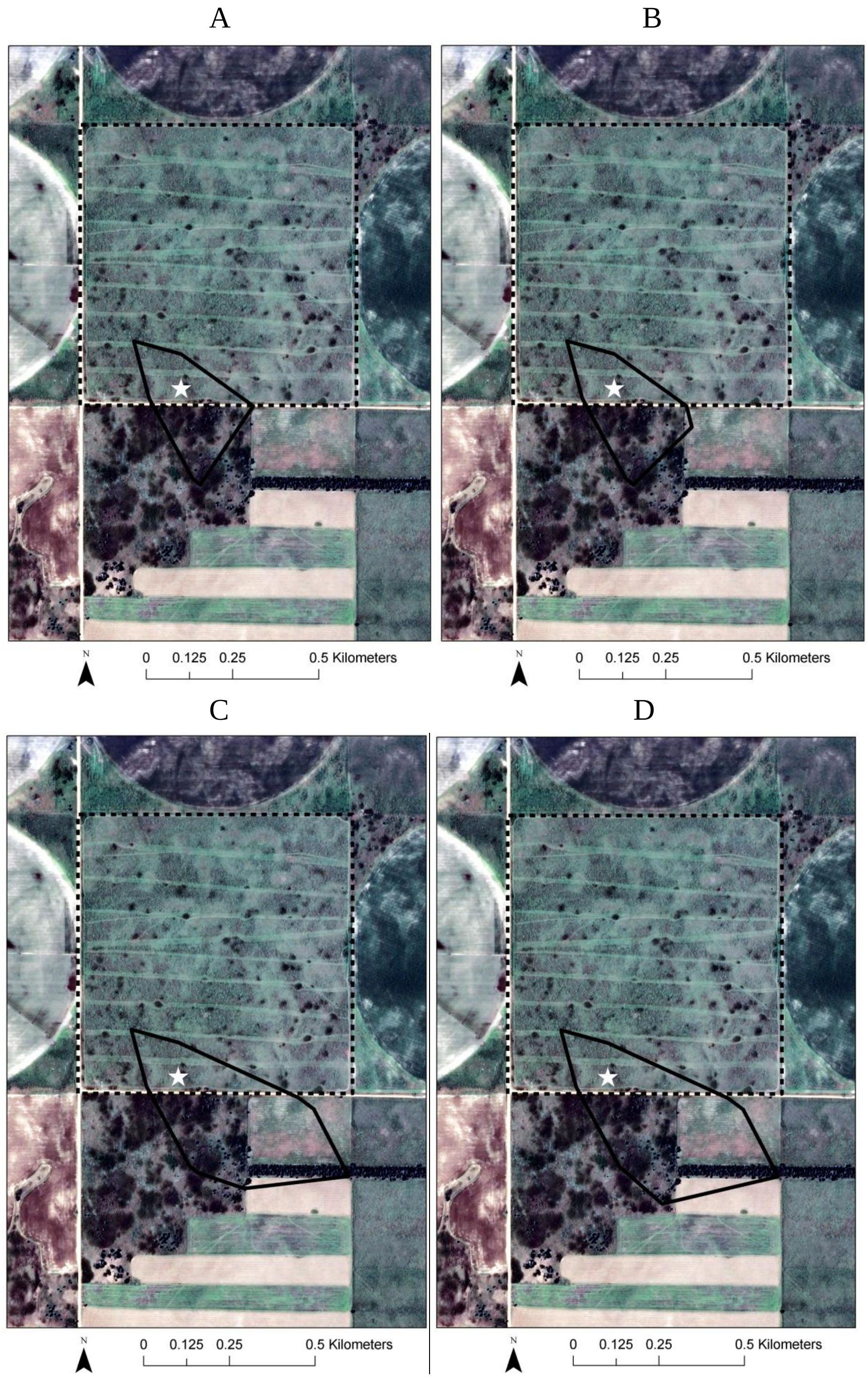

Figure 4. Combined home range of all transmittered surrogator Northern Bobwhites for 6 June field 3 release (n = 10) in Kiowa County, Kansas, 2010. Polygons increase from day 1–10 (A), 1–20 (B), 1–30 (C), and 1–40 (D). Surrogator location marked as star and perimeter of surrogator field marked with dash

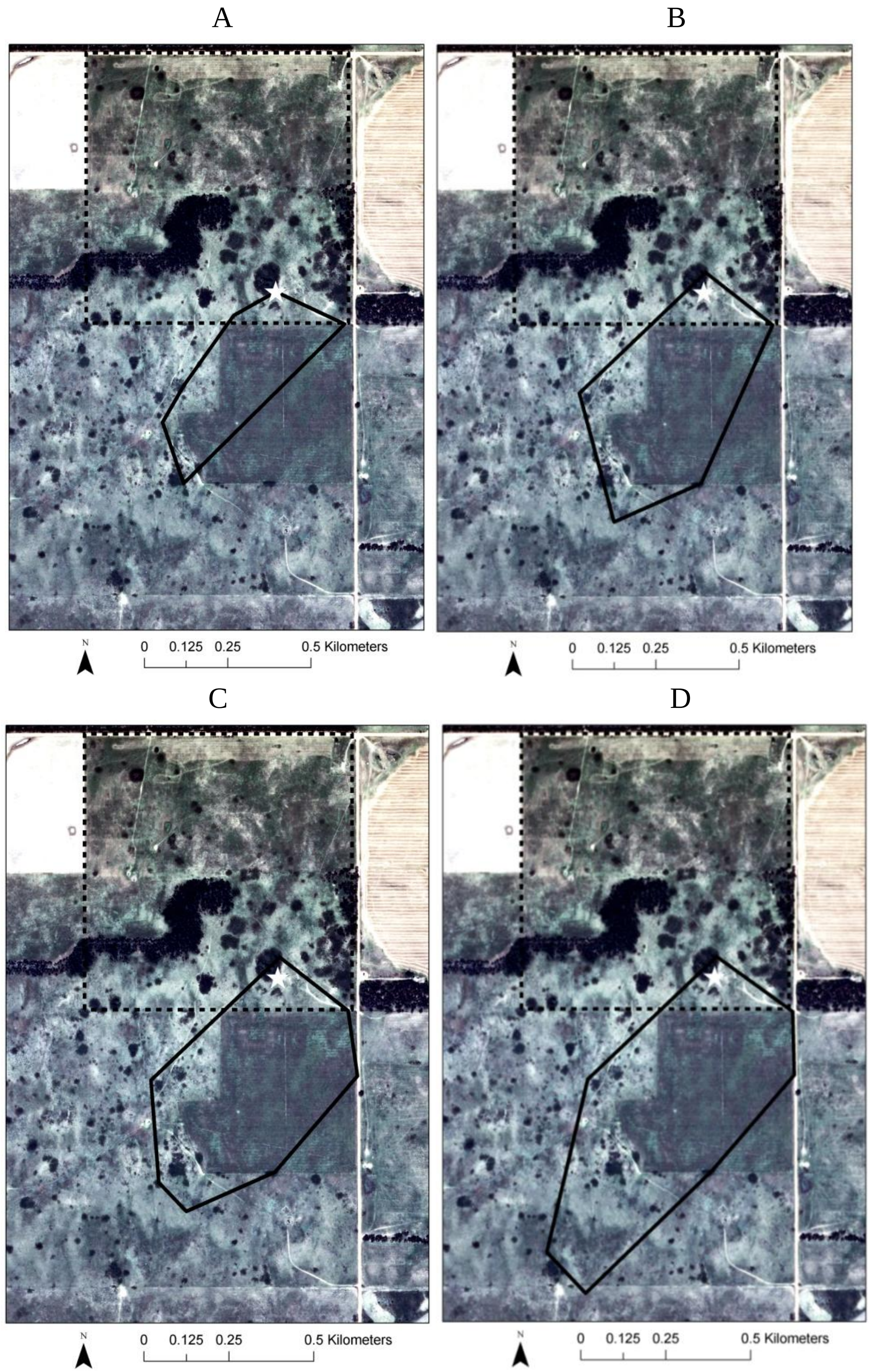

Figure 5. Combined home range of all transmittered surrogator Northern Bobwhites for 7 September field 17 release (*n* = 5) in Kiowa County, Kansas, 2010. Polygons increase from day 1–10 (A), 1–20 (B), 1–30 (C), and 1–40 (D). Surrogator location marked as star and perimeter of surrogator field marked with dash.

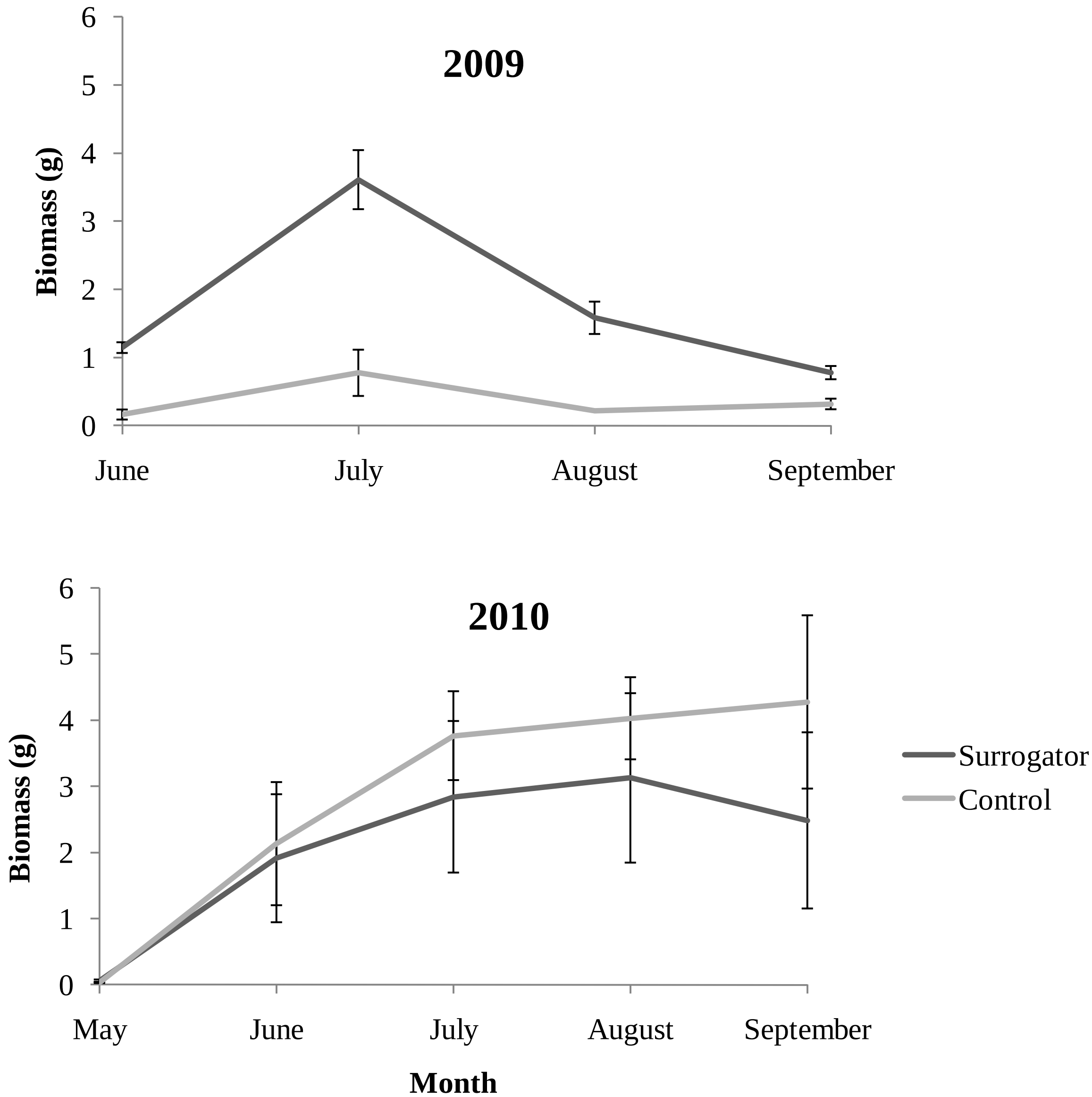

Figure 5. Mean biomass of invertebrates collected by month on control and surrogator fields in Kiowa County, Kansas, in 2009 and 2010.

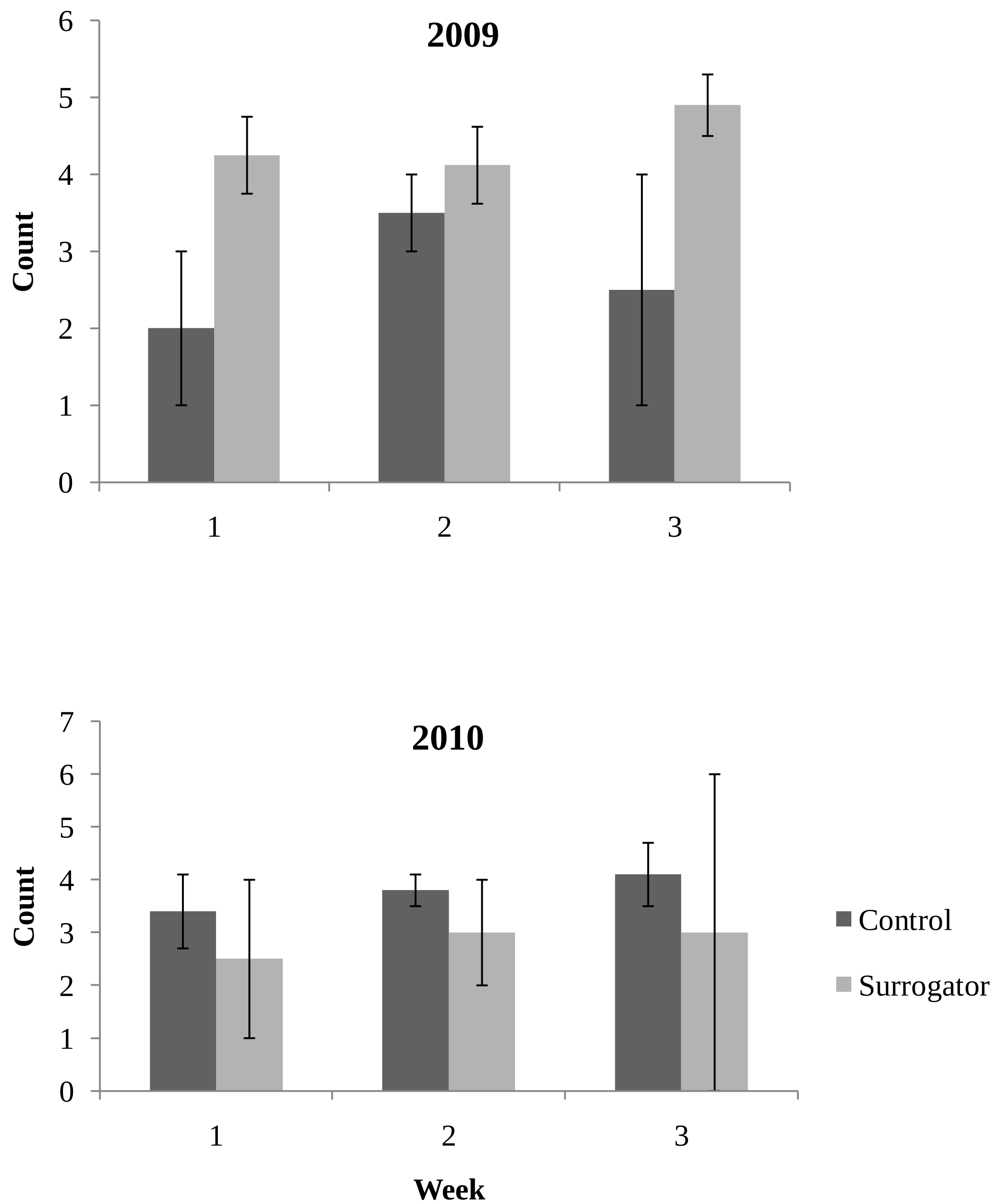

Figure 6. Spring “bobwhite” whistle counts (n = 30) on control and surrogator sites in Kiowa County, Kansas from 6 June through 15 July 2009 and 2010.

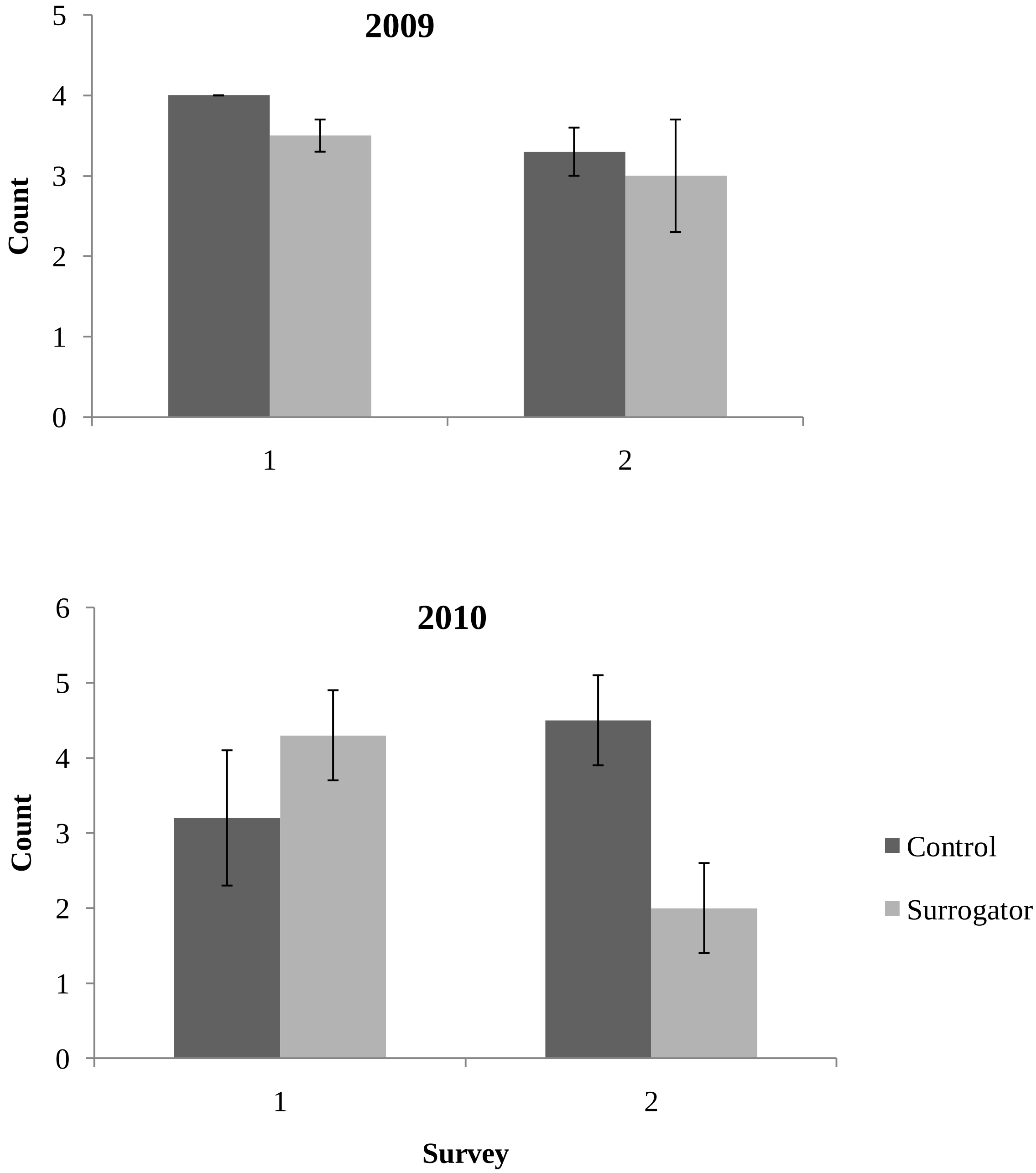

Figure 7. Fall covey "koi-lee" counts (*n* = 18) on control fields and surrogator fields in Kiowa County, Kansas from 3 October through 14 November 2009 and 2010.

CHAPTER III

INFLUENCE OF SURROGATOR® ON ENHANCING BOBWHITE QUAIL HUNTING

Jacob M. Hagen[1], R. Lee Hamm[1], Craig A. Davis[1] and Fred S. Guthery[1]
[1] *Department of Natural Resource Ecology and Management, Oklahoma State University, 008C Agricultural Hall, Stillwater, OK 74078*

Abstract: The Surrogator® (hereafter, surrogator) is a recently developed captive-rearing system that claims to establish a huntable population of gamebirds on a property. We examined the effectiveness of the surrogator to enhance northern bobwhite (*Colinus virginianus*) hunting. We conducted the study in Kiowa County, Kansas during the bobwhite hunting season from November–January 2009–2011. The primary objectives were to record surrogator bobwhites harvested, record dispersal distance of harvested bobwhites from their release site, and to record hunter opinion of surrogator bobwhites. We recorded surrogator bobwhite returns and dispersal data by discretely following hunting parties. We determined hunter opinion of surrogator bobwhites using a questionnaire. During the 2009–2010 hunting season, sportsmen harvested 13 surrogator bobwhite from 502 released, which comprised 20% of the total harvest. During the 2010–2011 hunting season, sportsmen harvested 66 surrogator bobwhite from 603 released birds, which comprised 37% of the total harvest. The average distance from the surrogator to where surrogator-released bobwhites were harvested was 273 m ± 90 (SE) (range: 150- 342 m) during the 2009-2010 hunting season and 634 m ± 137 (range: 43-2,832 m) in 2010-2011. Hunters rated the "wildness" of the surrogator bobwhite they harvested as 9.1 out of 10 (1 being tame and 10 being completely wild) during both hunting seasons. Surrogator bobwhites supplemented hunters bags at about the same return rate to a lower rate compared with other preseason pen-release methods. Dispersal off-property seemed to limit our hunter's ability to recover the birds during the hunting season. Given our findings, use of the surrogator to establish a population solely of surrogator bobwhites by the hunting season was not confirmed. Sportsmen may use the surrogator to supplement harvest of wild bobwhites, though hunter attitudes of benefits versus costs will vary.

Key Words: captive-rearing, Colinus virginianus, Kansas, northern bobwhite.

Corresponding Author:
Jacob Hagen, ph. (618) 980-3899, jacob.hagen@okstate.edu

INTRODUCTION

In many parts of the U.S., Northern Bobwhite (*Colinus virginianus*; hereafter, bobwhite) populations have declined dramatically. In the southeastern U.S., bobwhite populations have exhibited a 3.8% decrease per year (McKenzie 2009). Locales on the periphery of bobwhite range such as Ontario, Canada, have shown even more drastic declines (19.8% per year from 1966–1999) (Dailey 2002). An artifact of these declines has been a decline in bobwhite hunters. For example, areas that were once at the core of bobwhite hunting traditions have seen bobwhite hunter numbers plummet from 127,000 hunters to 30,000 hunters in less than 50 years (Georgia Game and Fish Commission Federal Aid Report 1965, Nicholson 2003). In Georgia, hunter harvest of bobwhites has also dropped markedly from nearly 3,400,000 birds in 1964 to 540,000 birds in 2002, of which nearly 70% were reported as pen-raised (Nicholson 2003). Similar declines in bobwhite harvest have occurred in other states steeped in hunting tradition, as Missouri's bobwhite harvest fell from roughly 4 million birds in 1969 to 300,000 birds in 2001 (Missouri Department of Conservation, unpublished data). Nationally, small game hunting participation (bobwhite hunting included) has declined by 68% between 1991 and 2006 (U.S. Fish and Wildlife Service 2006).

Even as bobwhite populations decline across much of their former range, many sportsmen are finding ways to pursue their favorite upland quarry. Studies have been published detailing how intensive habitat modifications have reversed local bobwhite declines (Brennan et al. 2000, Stribling and Sisson 2009, Terhune et al. 2009). However, many private landowners do not have the resources, time, or funds to properly manage habitat for bobwhites. Moreover, public recreation areas may support populations of bobwhite, but lottery draw systems or tremendous public hunting pressure vex and frustrate some would be sportsmen. Consequently, some hunters have attempted to raise and release pen-reared bobwhites to provide recreation during the hunting season (DeVos and Speake 1995).

There are many different techniques and variations to raising bobwhites in a captive environment for the purpose of releasing them onto a property. The basic and most general pen-rearing system can be described as placing young chicks in an enclosed environment that limits their exposure to the elements while providing access to food, water, and heat (Erbeck and Nunn 1999). Additionally, a flight cage may be included to foster stronger flight in the birds (Erbeck and Nunn 1999). The primary goal of pen-raising bobwhites is to produce birds with similar characteristics to wild bobwhites. Gamebird farmers usually try to limit contact with young chicks as the birds habituate easily (Kozicky 1993). Habituation is a primary complaint of sportsmen, as tame bobwhites are not as sporting (e.g., strong flight, elusive behavior, wild flushes) in the field as their wild counterparts.

There has been much debate about what method is best to release captive-raised birds. Some preserve managers attempt to avoid high mortality and erratic dispersal by releasing their game farm bobwhites minutes prior to the hunt (Berger 1977). Various techniques have been attempted to instill fidelity of upland birds to reintroductions sites, though they have had limited success (Aimee Wiese, Missouri Department of Conservation, personal communication; Oakley et al. 2002). Additionally, some sportsmen criticize the technique of releasing the birds minutes before the hunt because they perceived the birds as being habituated and poor flyers (Webb and Nelson 1971, Seal 1977, Kozicky 1993). In contrast, preseason released pen-raised birds that survive to the hunting season after a substantial period of acclimation (1–2 months in the wild after liberation) have been shown to fly stronger and farther, hold better, and flush as a covey compared to birds given a shorter acclimation period (DeVos and Speake 1995). Generally, preseason released bobwhites do not survive until hunting season in the sizeable populations that hunters desire (Baumgartner 1944). Hunting preserve owners who continually cycle large groups of bobwhite hunters through their properties need ample populations that provide consistent, satisfactory recreation for their guests (DeVos and Speake 1995, Guthery 2000, Evans et al. 2009). The problems associated with pen-released bobwhites are many, yet the demand for quality bobwhite hunting remains strong as sportsmen continue to seek how to best provide hunting recreation.

The surrogator is an in-field captive-rearing system that was designed to eliminate problems (e.g., low survival, erratic dispersal, poor athleticism) associated with conventional pen-reared techniques (Fig. 1). The primary claim of the manufacturer of the surrogator is that it will establish a huntable population of bobwhites on a property (Anonymous 2009). By placing the surrogator in the field where the birds will be released, this system may foster fidelity to that field and eliminate erratic dispersal normally associated with conventional pen-releases. The surrogator manufacturer claims that unlike adult pen-released bobwhites, surrogator birds released at 5 weeks of age retain their survival instincts. The surrogator contains a feeder, waterer, heater, and release door. One-day old bobwhite chicks are placed inside the unit and human contact is limited to prevent habituation. After 5 weeks, the release door is opened and the bobwhites leave freely. As bobwhite populations continue to decline, more sportsmen are likely to turn to pen-releasing birds to provide sport. Therefore, adequate research is needed to evaluate the surrogator so hunters and managers are provided with independent information on its merits. As little to no research has been done on the surrogator, this study intends to determine its effectiveness.

As one of the goals of releasing bobwhites on a property is to provide recreation, it is important to understand at what rate released birds are being recovered by hunters. A study of pen-released bobwhites in Texas reported a 7.5% return to bag of bobwhites released from May-September (Maple and Silvy 1988). Webb and Nelson (1971) reported 33.5% of preseason (2–10 weeks prior to opening day) released bobwhites were recovered by hunters. Other studies of harvest returns from pre-season released bobwhites range from 10–35% and subsequent year harvest returns are usually less than 1% (Beuchner 1950, Pierce 1951, Mueller 1984). Sportsmen who release captive-reared bobwhites desire the maximum amount of recreation possible so that their investment can be justified. One way to measure this is by the percent of birds released that are returned to bag. Another way hunters measure the success of pen-releases is by gauging similarities of pen-reared to wild bobwhites. Numerous studies have remarked that conventionally raised captive-released bobwhites were not favorably received by sportsman due to their dissimilarity to wild birds (Seal 1977, Kozicky 1993, DeVos and

Speak 1995). Sportsmen continue to seek a method of captive-rearing that produces bobwhites with the elusive and athletic behavior wild bobwhites exhibit.

To assess the influence of the surrogator on enhancing bobwhite hunting, we recorded band return rates within release field as well as by hunters reporting band returns off release site. We recorded band returns and other hunting parameters by discretely following hunters throughout each hunt. Surrogator bobwhite dispersal was determined by calculating distance from harvest site to surrogator-release. Hunter opinion of surrogator bobwhites was assessed using a questionnaire given to hunters. As bobwhite populations decline, sportsmen are turning to various techniques to provide abundances of game in lieu of natural populations. This project aims to evaluate the surrogator, a recently popular bobwhite restoration technique, and use our findings to inform bobwhite enthusiasts on its effectiveness in enhancing hunting.

METHODS

Study Area

The study was conducted on private pastureland and fields enrolled in the Conservation Reserve Program (CRP) near Greensburg, Kansas in Kiowa County. The physiography of the area is defined by gently rolling sandy plains with elevations between 400 and 800 m (U.S. Environmental Protection Agency 2007). The area is characterized by cattle pastures, dryland crops such as wheat and milo, center pivot irrigated crops such as corn and soybeans, and CRP fields. The CRP fields on which the research was conducted were planted in the late 1980's following guidelines for the CP-2 program (Ray Colglazier, Natural Resources Conservation Service, personal communication). The CP-2 program is a native warm season grass mixture that includes indian grass (*Sorghastrum nutans*), little bluestem (*Schizachyrium scoparium*), big bluestem (*Andropogon gerardii*), switchgrass (*Panicum virgatum*), sand love grass (*Eragrostis trichoides*), and side oats grama (*Bouteloua curtipendula*) Fields ranged in size from 64 to 160 ha.

Study Setup

Surrogators were employed on 2 research fields during the 2009 field season. One other research field was used as a control field in 2009. In 2010, treatment fields were switched. Also in 2010, one surrogator field was added which previously had not been a control field. Bobwhites were raised in the surrogator according to Wildlife Management Technologies 2009 Surrogator System Guide (Anonymous 2008). Prior to release, bobwhites were banded with a number 7 aluminum leg bands (National Band and Tag Co., Newport, Kentucky, USA). Bands had a unique identification number and a phone number for sportsmen harvesting bobwhites off-property to call in and report harvest. In both years, 6 groups of surrogator chicks were released, with approximately 3 releases per field.

Monitoring Hunts

We monitored bobwhite hunts from mid November through late January during the 2009–2010 and 2010–2011 hunting seasons. Hunts were monitored to assess the effectiveness of the surrogator at enhancing hunting opportunities. During both hunting seasons, a guide led his clients and guests in hunts on research fields. All decisions on hunting (i.e., group size, dogs, duration, location, timing) were made by the outfitter, and we simply observed the hunters by following them at a distance as to not interfere or influence their hunt. We recorded a variety of data such as group size, hunt duration, birds harvested (banded or wild), activity budgets (% of time in behaviors), and hunter and dog velocity. Hunter movements were recorded by attaching Garmin Foretrex 201 GPS units to the outside of a hunter's vest. Tracks were then converted to distance and velocity using Minnesota Department of Natural Resources Garmin 5.1.1 software. Hunter behavior was visually monitored by following an individual hunter from each hunting party from the beginning of a hunt until the end of a hunt. We recorded amount of time engaged in the following 6 behaviors: 1. approaching dog on point, 2. hunting for live singles, 3. resting, 4. searching for dog, 5. searching for downed birds, and 6. walking (Mecozzi and Guthery 2008). If a banded bird was recovered, its flush site was marked with a GPS and distance from its surrogator release site determined using GIS applications. Banded bird recovery rates were determined by dividing the number harvested by the number released. Finally, a hunter information survey was distributed to participating hunters (Appendix A). The survey allowed us to gather demographic information about hunters, as well as assess their attitudes toward surrogator birds if they harvested any. The Oklahoma State Institutional Review Board approved use of human subjects for our study (Permit # AG10943).

RESULTS

Hunting Variables

During the 2009–2010 bobwhite hunting season, we monitored 6 hunts on the control field (Table 1). Average group size was 10 sportsmen and mean hunt duration was 75.6 min ± 14.3 (SE) (range: 30–120 min). No bobwhites were harvested in 454 min of total hunting time. We monitored 12 hunts on surrogator fields. Average group size on surrogator fields was 8 hunters and mean hunt duration was 92 min ± 19.2 (range: 19–238 min). Of 502 surrogator bobwhite released on surrogator fields, 7 were returned by our hunters in 1,108 total min of hunting time. Surrogator bobwhite comprised 16% (7/43) of the total bobwhite harvest on surrogator fields for the 2009–2010 season. The total band return rate (our hunter's harvest plus banded bobwhites harvested off property and called in/total birds released) was 2.6% (Table 2). The early releases on 11 Aug comprised all of the band returns and no band returns were recorded for the late release (27 Sep).

Variation in hunter activity budgets between control and surrogator field was most apparent for the in-between pass category (Table 3). This variation was due to the layout of surrogator fields, which restricted vehicle access. All activities associated with bobwhite encounters were lower on the control field, as no bobwhites were harvested in that field.

During the 2010–2011 hunting season, we monitored 13 hunts on control fields. Average group size was 6 hunters and mean hunt duration was 89.6 min ± 7.3 (range: 15–227 min). Hunters harvested 22 wild bobwhite and 1 surrogator bobwhite from the previous year's release in 1,165 min of total hunting time. We monitored 18 hunts on surrogator fields, where average group size was 7 hunters and mean hunt duration was 113.2 min ± 15.5 (range: 19–185 min). Of 603 bobwhite released on surrogator fields, 18 were returned during hunting on site in 2,308 min of total hunting time. Surrogator bobwhite comprised 30% (18/61) of the total harvest from surrogator fields. The total band return rate (our hunter's harvest plus banded bobwhites harvested off property and called in/total birds released) was 11% (Table 2). Earlier releases again had greater proportions of bobwhites harvested than later releases. Hunter activity budgets for control and surrogator fields were very similar for all categories with the exception of in-between pass (Table 3). Again the variation between fields was due to their layout.

Hunter and Dog Velocity

During the 2009–2010 bobwhite season, mean control field velocities of both hunters and dogs were slower than their respective categories on surrogator fields (Table 1). Average hunter velocity on the control field was 0.58 m/sec ± 0.09 (n = 3, range: 0.40–0.68 m/sec) compared to 0.72 m/sec ± 0.07 (n = 3, range: 0.58-0.83 m/sec) on surrogator fields. Mean dog velocity on the control field was 1.95 m/sec ± 0.28 (n = 3, range: 1.64–2.53 m/sec), compared to 2.82 m/sec ± 0.54 (n = 2, range: 2.28-3.36 m/sec) on surrogator fields. Breeds of dogs used were English pointers, German short-hair pointers, and Labrador retrievers.

Similar to the 2009-2010 hunting season, the velocities of both hunters and dogs were slower in control fields than surrogator fields during 2010–2011 hunting season (Table 1). Average hunter velocity on control fields was 0.57 m/sec ± 0.03 (n = 2, range: 0.51–0.61 m/sec), compared to 1.00 m/sec ± 0.16 (n = 6, range: 0.71–0.72 m/sec) on surrogator fields. Average dog velocity on control fields was 2.55 m/sec ± 0.36 (n = 3, range: 1.46–3.00 m/sec), compared to 3.54 m/sec ± 0.61 (n = 4, range: 2.28–5.80 m/sec) on surrogator fields.

Bobwhite dispersal

Of 13 surrogator bobwhite harvested in the 2009–2010 hunting season, we were able to obtain GPS locations on 7 locations where the birds were harvested. The mean distance from the harvest site to surrogator was 273 m ± 90 (range: 150–342 m). This number is undoubtedly biased low as we were only able to record GPS locations from sites where bobwhites were harvested within our fields.

Of 66 total surrogator bobwhite harvested offsite and onsite from 2010–2011, we were able to obtain approximate GPS locations for 18 of them (again mostly harvest sites on our property thereby biasing the distance low). Average distance from harvest site to surrogator was 634 m ± 137 (range: 43–2,832 m).

Hunter questionnaire

Hunters were asked to rate surrogator bobwhites that they harvested on a scale of 1-10 (1 being tame and 10 being completely wild), and our hunters on average rated them as 9.1 ± 0.2 (range: 5–10). Hunter demographics (n = 63 hunters) were also compiled which revealed that the average age of our hunters was 41 ± 1.8 years and our hunters had 22 ± 2.1 years of experience hunting and hunted bobwhites approximately 7 ± 1.5 times a year.

DISCUSSION

Hunting Variables

Bobwhite hunters in Kansas in the last decade (1999–2009) hunted an average of 5.2 days per season and harvested 1.35 bobwhites per day (Rogers 2010). Harvest data of bobwhites from the Kansas Department of Wildlife and Parks exhibited slight variation in average bobwhite harvest per day over the past decade (range: 0.92–1.64 bobwhites harvested/day) (Rogers 2010). Comparatively, hunters on surrogator fields in 2009–2010 made 12 hunting trips (9 days) to surrogator fields and harvested an average of 0.47 bobwhite (wild and banded) per hunter per day (0.39 wild bobwhite per hunter and 0.08 surrogator bobwhite per hunter). In 2010–2011, sportsmen made 18 trips (14 days) to surrogator fields and harvested an average of 0.51 bobwhite (wild and banded) per hunter per day (0.36 wild bobwhite per hunter and 0.15 surrogator bobwhite per hunter). These findings reveal that hunters on surrogator fields hunted more days and harvested less bobwhites compared to the Kansas average.

Size, strategy, and skill of hunters and dogs play a large role in determining harvest rates. Bobwhites run ahead of hunters or flush out of range in an attempt to evade their pursuers (Sisson et al. 2000). It has been reported that hunting parties locate on average 50% of bobwhites in a particular field, though this is influenced by many factors and can vary (Kellogg et al. 1982, Sisson et al. 2000). When comparing harvest rates and hunting parameters it is important to keep in mind the myriad of factors that influence hunting success.

Palmer et al. (2002) recorded hunting party information on bobwhite hunts in Florida over a 26-year period and found that average hunt duration was 138 min and mean trips per field per year was 4.4. Mecozzi and Guthery (2008) reported mean hunt durations of 82.3 min and 50.2 min in Oklahoma, Missouri, and Texas during the bobwhite hunting season in 2005–2006 and 2006–2007, respectively. These numbers compare to our mean hunt time of 86.7 min on control fields and 103.3 min on surrogator-release fields (2009-2010 and 2010-2011 combined). Our hunters made an average of 6.3 trips per control field and 7.5 trips per release field (2009–2010 and 2010–2011 combined). Ideally in our study, hunting variables (i.e., group size, hunt duration, hunter skill, hunter effort, and trips per field) would have been kept constant between control and surrogator fields and years or had been randomized to avoid bias and ensure independence. As mentioned previously, we were not in control of any aspect of hunting and followed the outfitter and his hunters at their will. Our data are not directly comparable to the above bobwhite hunting studies, as our hunters were both bobwhite and pheasant hunting, but it provides some reference and insight into bobwhite hunting dynamics.

Compared to previous studies, bands of surrogator bobwhites were returned at lower rates. During the 2009–2010 hunting season, 13 surrogator bobwhite were harvested by hunters for a return rate of 2.6%. During the 2010–2011 hunting season, 66 surrogator bobwhite were harvested by hunters for a return rate of 10.9%. Literature published on return rates of pen-released bobwhites range from roughly 7–35% (Beuchner 1950, Pierce 1951, Webb and Nelson 1971, Mueller 1984, Maple and Silvy 1988). Band returns of surrogator bobwhites may have been lower than previous studies due to lower survival and dispersal off release site which hindered our hunter's ability to pursue them (J. M. Hagen, unpublished data). Band returns of quail released in 2009 and harvested the following hunting season were less than 1% as another study had also reported (Beuchner 1950). The ability of 1.5-year-old surrogator birds to provide recreation seems extremely limited. Even in wild populations, juveniles make up the majority of harvest (roughly 80%) (Rosene 1969). Sportsmen generally expect pen-released birds to provide recreation for that year's hunting season only and any additional survival would be welcomed, but not assumed (Evans et al. 2009).

Our band return rates are conservative, as we heard of and knew more bands were harvested by hunters off-site, but these bands were not reported. Similar problems occur for the federal waterfowl banding program (U.S. Fish and Wildlife Service 2011) which estimates that hunters only report 30–40% of all banded waterfowl harvested. We attempted to make sportsmen aware of our research project by posting flyers that requested upland hunters to report any banded bobwhites that were harvested. Because bands are not commonly observed on bobwhite (unlike waterfowl), we received numerous comments that hunters almost missed seeing the band. Other hunters remarked how small the band was and that they had trouble correctly reading the band number and contact phone number.

Hunter and Dog Velocity

Our mean hunter velocity combined for both years and research fields was 0.73 m/sec, which was similar to previous estimates for hunter velocity by Mecozzi and Guthery (2008) and Richardson (2006) who reported 0.8 m/sec and 0.73–0.77 m/sec, respectively, for bobwhite hunters. Mean dog velocity combined for both years and research fields was 2.71 m/sec, which was also similar to previous studies by Mecozzi and Guthery (2008) (2.5 m/sec) and Hardin et al. (2005) (2.3-3.0 m/sec). Both our hunter and dog velocity estimates are quite similar to previous reports suggesting similar hunting party pace across studies.

There was an obvious discrepancy between both hunter and dog velocities on release fields and control fields. A possible explanation for this is simply that where hunters anticipate birds are plentiful (i.e., surrogator fields) they walk faster, eager to flush them, but where they do not expect to flush birds (control fields) they slow their pace as they assume nothing exciting awaits them ahead (J. M. Hagen, personal observation). Vegetative characteristics did not appear to influence hunter and dog velocity as velocities were not similar between years per field with and without the surrogator. Mecozzi and Guthery (2008) contradict this hypothesis as they found similar hunter velocity rates in years of high and low bobwhite population. The exact cause of why surrogator fields had higher hunter and dog velocities in both years is unknown. The influence of factors such as topography, hunter health, hunt strategy, group size, and dog experience on velocity rates for our study is unknown, but it has been reported that these are important factors that may influence the hunter and dog during hunting (Richardson 2006).

Bobwhite Dispersal

Our mean combined dispersal distance of 454 m was hampered by our inability to access all harvest sites because most (63%) of the birds were harvested off-site. Our dispersal estimate is undoubtedly biased low. Sportsmen who harvested surrogator bobwhites off property had difficulties reporting the precise harvest site, but the estimated harvest site ranged from directly across the fence of a research property to roughly 3 km away. A study by Eggert et al. (2009) reported a linear dispersal distance of 399.4 m from pen-release site to the farthest observed location during the winter for bobwhites. Baumgartner (1944) reported a range of 1.2-12.9 km linear dispersal distance of 10 game-farm quail harvested by hunters. One study of wild bobwhite dispersal found that of radiomarked bobwhites, 17% never moved more than 1 km from their capture location, 42% moved between 1-2 km, and 41% moved greater than 2 km (Townsend et al. 2003). Compared with these results, surrogator bobwhite dispersal rates were similar to previous studies.

Surrogator quail were found mixed with wild birds during the hunting season as some birds shot from a covey rise were banded and some not. This finding dispels what has previously been reported about pen and wild bobwhite interaction (Kozicky 1972) and further confirms that pen-raised and wild birds will mix to form coveys (DeVos and Speake 1995, Eggert et al. 2009). This is important as even though surrogator bobwhites were not solely able to establish a population, they did join with wild birds and contribute to hunter harvest. Some researchers are concerned whether game farm bobwhite interaction with wild bobwhites may facilitate disease introduction (Erbeck and Nunn 1999). There is also evidence that interbreeding between pen-reared and wild bobwhites decreases genetic diversity (Evans et al. 2009). The implications of these 2 factors should be considered when releasing pen-reared bobwhites.

Hunter Questionnaire

The hunter rating of surrogator birds (9.1 out of 10 both years) seems to confirm DeVos and Speake's (1995) assertion that after 1–2 months afield, pen-liberated bobwhites were nearly indistinguishable from wild birds. However, 2 of the hunters did comment that surrogator bobwhites were feathered differently and were larger compared to wild birds. These were the only comments recorded that distinguished surrogator bobwhites from wild birds. It appears surrogator bobwhites were favorably received by our hunters and the similarity to wild birds was accomplished. We did not obtain information on what type of upland hunting (wild or pen-reared) our sportsmen had experience with, but this information could further elucidate how well surrogator bobwhites compared to wild birds.

We did not follow the Mecozzi and Guthery (2008) protocol identically with respect to hunter behavior categories, as our hunts were structured differently (pheasant and bobwhite combination hunts) and some of the data they collected were not possible for us to obtain. One example of how our hunts were structured differently was how our hunters walked fields in passes in order to hunt with the wind. The group would release 3–5 dogs then follow in a line behind them, walking into the wind to the end of the field. Another hunter would drive a vehicle to meet the walking hunters at the end. Once the walkers reached the end of the pass, they would load the dogs into their kennels, and sit on the trailer, which was then driven around to the next pass to hunt into the wind again. Hunting of singles as is conventionally done in bobwhite hunting (Mecozzi and Guthery 2008) was rarely pursued due to the difficulties with group size. The hunting guide used large groups of hunters to cover wide sections of CRP and pasture fields, but this made pursuit of bobwhite singles dangerous as hunters would have been at risk of firing at each other. We also were not able to record dog behavior as Mecozzi and Guthery (2008) did due to thick vegetation which prevented viewing wide ranging dogs. It was also difficult to accurately record how many dogs were used as these numbers normally changed after each pass. Generally, 4 dogs were used per pass, but as it was so difficult to accurately record and differentiate a mean number of dogs used per field; we simply state this as an approximate value. Our data may not be directly comparable to other upland hunting studies, but these previous studies assisted in guiding our research and they allowed insight into bobwhite hunting dynamics.

MANAGEMENT IMPLICATIONS

Compared to previous pen-release studies, surrogator bobwhites were recovered at slightly lower rates. Use of the surrogator did supplement wild bobwhite harvest by an average of 31% per year. Surrogator bobwhite dispersal offsite restricted our hunter’s ability to recover birds, as 63% of band returns were from hunters harvesting banded birds offsite.

Hunting data revealed that surrogator hunters made more trips, but were less successful than the average Kansas bobwhite hunter. Hunter's opinion of surrogator birds was generally favorable, as sportsmen rated their wildness as 9.1 out of 10. These findings conclude that without the existence of wild bobwhites, hunter-covey encounters would have been much less. Given these findings, establishment of a huntable population of bobwhites strictly from the surrogator may be difficult. Some sportsmen may find use for the surrogator as a tool to supplement wild population, though varying attitudes on benefit versus cost may make return rates unjustifiable. Justification and utilization of the surrogator is dependent on one's goals and resources and may or may not be of use for those purposes.

ACKNOWLEDGMENTS

Funding and assistance for this project was provided Wildlife Management Technologies, Frank W. Merrick Foundation Management, Game Bird Research Fund, Oklahoma State University's Department of Natural Resources Ecology and Management and the Oklahoma Cooperative Fish and Wildlife Research Unit. Technical assistance and guidance was provided by Dwayne Elmore, Jason Johnson, Matt White, Mark Gregory, and various Oklahoma State graduate students.

LITERATURE CITED

Anonymous. 2008. Wildlife management technologies 2009 surrogator system guide. Wildlife Management Technologies, Wichita, Kansas, USA.

Anonymous. 2009. Wildlife management technologies product catalog. Wildlife Management Technologies, Wichita, Kansas, USA.

Baumgartner, F. M. 1944. Dispersal and survival of game farm bobwhite quail in northcentral Oklahoma. Journal of Wildlife Management 8:112–118.

Berger, A. J. 1977. Fitness of offspring from captive populations. Pages 315–320 *in* S. A. Temple, editor. Endangered birds: management techniques for preserving threatened species. University of Wisconsin, Madison, USA.

Beuchner, H. K. 1950. An evaluation of restocking with pen-reared bobwhite. Journal of Wildlife Management 14:363–377.

Brennan, L. A., J. M. Lee, and R. S. Fuller. 2000. Long-term trends of northern bobwhite populations and hunting success on private shooting plantations in northern Florida and southern Georgia. Pages 75–77 *in* L. A. Brennan, W. E. Palmer, L. W. Burger and T. L. Pruden, editors. Quail IV: Proceedings of the Fourth National Quail Symposium. Tall Timbers Research Station, Tallahassee, Florida, USA.

Dailey, T. V. 2002. Emerging trends in Midwest bobwhite culture. Pages 8–19 *in* S. J. DeMaso, W. P. Kuvlesky, Jr., F. Herna´ndez, and M. E. Berger, eds. Quail V: Proceedings of the Fifth National Quail Symposium. Texas Parks and Wildlife Department, Austin, TX, USA.

DeVos, T. and D. W. Speake. 1995. Effects of releasing pen raised northern bobwhites on survival rates of wild populations of northern bobwhites. Wildlife Society Bulletin 23:267–273.

Eggert, D. A, B. S., Mueller, L. Robinette, and S. D. Wellendorf. 2009. Comparison of survival, productivity, movements, and habitat use of pre-season released quail on wild northern bobwhites on Groton Plantation, South Carolina. Pages 396–408 *in* Cederbaum S. B., Faircloth B. C., Terhune T. M., Thompson J. J., Carroll J. P., eds. Gamebird 2006: Quail VI and Perdix XII. 31 May – 4 June 2006. Warnell School of Forestry and Natural Resources, Athens, GA, USA.

Erbeck, D. H. and S. A. Nunn. 1999. Chlaydiosis in pen raised bobwhite quail (*Colinus virginianus*) and chukar partridge (*Alectoris chukar*) with high mortality. Avian Diseases 43: 798–803.

Evans, K. O., M. D., Smith, L. W. Burger Jr., R. J., Chambers, A. E., Houston and R. Carlisle. 2009. Release of pen-reared bobwhites: potential consequences to the genetic integrity of resident wild populations. Pages 121–133 *in* S. B. Cedarbaum, B. C. Faircloth, T. M. Terhune, J. J. Thompson, J. P. Carroll, editors. Gamebird 2006: Quail VI and Perdix XII. 31 May – 4 June 2006. Warnell School of Forestry and Natural Resources, Athens, Georgia, USA.

Georgia Game and Fish Commission. 1965. Annual report: federal aid in wildlife restoration research. Georgia Game and Fish Commission, Atlanta, Georgia, USA.

Guthery, F. S. 2000. On bobwhites. Texas A&M University, College Station, Texas, USA.

Hardin, J. B., L. A. Brennan, F. Hernandez, E. J. Redeker, and W. P. Kuvlesky, Jr. 2005. Empirical tests of the hunter-covey interface models. Journal of Wildlife Management 69:498–515.

Kellogg, F. E., G. L. Doster, W. R. Davidson, and W. M. Martin. 1982. Efficiency of dogs in locating bobwhites. Pages 31–34 *in* Quail II: National Quail Symposium. Oklahoma State University, Stillwater, Oklahoma, USA.

Kozicky, E. L. 1972. Bobwhite quail on shooting preserves. Pages 1–7 *in* J. A. Morrison and J. C. Lewis, editors. Quail I: first national bobwhite quail symposium. Oklahoma State University, Stillwater, Oklahoma, USA.

Kozicky, E. L. 1993. The history of quail management with comments on pen-rearing. Pages 1–7 *in* K. E. Church and T. V. Dailey, editors. Quail III: national quail symposium. Kansas Department Wildlife and Parks, Pratt, Kansas, USA.

Maple, D. P. and N. J. Silvy. 1988. Recovery and economics of pen-reared bobwhites in north-central Texas. Proceedings of the Annual Conference of Southeastern Fish and Wildlife Associations 42: 329–332.

McKenzie, D. F. 2009. Taking the northern bobwhite conservation initiative to the next level. Pages 16–23 *in* S. B. Cedarbaum, B. C. Faircloth, T. M. Terhune, J. J. Thompson, J. P. Carroll, editors. Gamebird 2006: Quail VI and Perdix XII. 31 May – 4 June 2006. Warnell School of Forestry and Natural Resources, Athens, Georgia, USA.

Mecozzi, G. E. and F. S. Guthery. 2008. Behavior of walk-hunters and pointing dogs during northern bobwhite hunts. Journal of Wildlife Management 72:1399–1404.

Mueller, B. S. 1984. Final Report: an evaluation of releasing pen-raised quail in the fall. Quail Unlimited 2:6–8,26.

Nicholson, W. S. 2003. Harvest of wildlife in Georgia. Federal Aid Project W-55, Georgia Wildlife Surveys. Georgia Game and Fish Commission, Atlanta, Georgia, USA.

Oakley, M. J., D. L. Bounds, T. A. Mollett, and E. C. Soutiere. 2002. Survival and home range estimates of pen-raised northern bobwhites in buffer strip and non-buffer strip habitats. Pages 74–80 *in* S. J. DeMaso, W. P. Kuvlesky, Jr., F. Hernandez, and M. E. Berger, eds. Quail V: Proceedings of the Fifth National Quail Symposium. Texas Parks and Wildlife Department, Austin, TX, USA.

Palmer, W. E., S. D. Wellendorf, L. A. Brennan, W. R. Davidson, and F. E. Kellogg. 2002. Hunting success and northern bobwhite density on Tall Timbers Research Station: 1970–2001. Pages 213–216 *in* S. J. DeMaso, W. P. Kuvlesky, Jr., F. Herna´ndez, and M. E. Berger, eds. Quail V: Proceedings of the Fifth National Quail Symposium. Texas Parks and Wildlife Department, Austin, TX, USA.

Pierce, R. A. 1951. Survival of pen-reared bobwhite. Final Rep., Pittman-Robertson Pro. W-6-R. Kentucky Division of Fish and Game. 164pp.

Richardson, J. L. 2006. Comparison of cover selection by bobwhite quail and quail hunters in western Oklahoma. Thesis, Oklahoma State University, Stillwater, USA.

Rogers, R. 2010. Small game hunter activity survey-2009: Statewide wildlife research and surveys performance report. Kansas Department of Wildlife and Parks. Pittman-Robertson Funds Federal Aid in Wildlife Restoration Grant W-39-R-16. Pratt, Kansas, USA.

Rosene, W. 1969. The bobwhite quail: It's life and management. Rutgers University Press New Brunswick, New Jersey. 418pp

Seal, U. S. 1977. The Noah's ark problem: multigenerational management of wild species in captivity. Pages 303–314 *in* S. A. Temple, editor. Endangered birds: management techniques for preserving threatened species. University of Wisconsin, Madison, Wisconsin, USA.

Sisson, D. C., D. W. Speake, and H. L. Stribling. 2000. Survival of northern bobwhites on areas with and without liberated bobwhites. Pages 92–94 *in* L. A. Brennan, W. E. Palmer, L. W. Burger, Jr., and T. L. Pruden. Quail IV: Proceedings of the Fourth National Quail Symposium. Tall Timbers Research Station, Tallahassee, Florida, USA.

Stribling, H. L. and D. C. Sisson. 2009. Hunting success on Albany, Georgia plantations: the Albany quail project's modern quail management strategy. Pages 338–347 *in* S. B. Cedarbaum, B. C. Faircloth, T. M. Terhune, J. J. Thompson, J. P. Carroll, editors. Gamebird 2006: Quail VI and Perdix XII. 31 May – 4 June 2006. Warnell School of Forestry and Natural Resources, Athens, Georgia, USA.

Terhune, T. M., D. C. Sisson, S. Mitchell, and H. L. Stribling. 2009. Northern bobwhite demographic and population response following an intensive habitat modification an agriculture landscape. Pages 232–249 *in* S. B. Cedarbaum, B. C. Faircloth, T. M. Terhune, J. J. Thompson, J. P. Carroll, editors. Gamebird 2006: Quail VI and Perdix XII. 31 May – 4 June 2006. Warnell School of Forestry and Natural Resources, Athens, Georgia, USA.

U.S. Department of the Interior, Fish and Wildlife Service. 2006. Trends in fishing and hunting 1991–2006: a focus on fishing and hunting by species. Report 2006-8.

U.S. Fish and Wildlife Service. 2011. Migratory Bird Program; Bird Monitoring. <http://www.fws.gov/migratorybirds/SurveysMonitoringResearch/mntrtbl.html> Accessed 9 June 2011

U. S. Environmental Protection Agency. 2011. Western Ecology Division: Ecoregions of Kansas and Nebraska.<http://www.epa.gov/wed/pages/ecoregions/ksne_eco.htm>. Accessed 30 Jan 2010.

Webb, L. G. and F. P. Nelson. 1971. Recovery data from pen-raised quail released before and during the hunt season. Proceedings of the Annual Conference of Southeastern Fish and Wildlife Associations 25:140–147.

TABLES AND FIGURES

Table 1. Northern Bobwhite hunt monitoring data for 2009-2011 on research fields in Kiowa County, Kansas. Range in parenthesis for mean hunt duration and mean group size.

	2009-2010		2010-2011	
Hunting parameters	Control	Surrogator	Control	Surrogator
Trips per field	6	12	13	18
Mean hunt duration (min)	75 (30–120)	92 (19–238)	90 (15–227)	113 (19–185)
Mean group size	10 (8–14)	8 (2–22)	6 (2–17)	7 (3–13)
Total birds released	NA	502	NA	603
Banded birds killed	NA	7	NA	18
Wild birds killed	0	36	22	43
Mean hunter velocity (m/sec)	0.58	0.75	0.57	1.00
Mean dog velocity (m/sec)	1.95	2.83	2.55	3.53

Table 2. Band returns of surrogator Northern Bobwhites in Kiowa County, Kansas, during the 2009–2011 hunting seasons.

Variables	2009–2010	2010–2011
Early release[1]	NA	32
Recovery rate	NA	14%
Mid release[2]	13	22
Recovery rate	5%	11%
Late release[3]	0	12
Recovery rate	0%	7%
Total harvested	13	66
Total released	502	603
Recovery rate	3%	11%
Harvested offsite	6	48
Harvested onsite	7	18

[1] In 2009 there were no early bobwhite releases. In 2010 releases were on 15 June.

[2] Release dates were 11 August 2009 and 28 June and 10 August 2010.

[3] Release dates were 27 September 2009 and 7 September 2010.

Table 3. Activity (%) budget of Northern Bobwhite hunters on control (*n* = 1) and surrogator fields (*n* = 9) in 2009–2010 and control (*n* = 5) and surrogator fields (n = 6) in 2010–2011 in Kiowa County, Kansas.

	2009-2010						2010-2011					
	Control			Surrogator			Control			Surrogator		
Behavior	Mean	SE	Range	Mean	SE	Range	Mean	SE	Range	Mean	SE	Range
Walking	55.0	NA	NA	82.2	12.6	18.0-117.0	77.0	13.1	22.0–96.0	52.6	12.6	44.0–124.0
In-between pass[1]	29.0	NA	NA	9.4	6.6	0.0-60.0	5.5	2.1	0.0–11.0	29.7	13.4	0.0–78.0
Searching for downed birds	0.0	NA	NA	1.8	0.6	0.0-4.0	6.7	1.9	0.0–12.0	6.3	3.9	2.0–25.0
Resting	0.0	NA	NA	2.7	0.4	0.0-4.0	7.9	1.1	4.0–10.0	5.6	2.4	3.0–19.0
Approaching dog on point	2.0	NA	NA	2.6	1.0	0.0-9.0	1.9	1.1	0.0–6.0	2.9	2.7	1.0–17.0
Hunting for live singles	0.0	NA	NA	0.0	0.0	0.0-0.0	0.0	0.0	0.0–0.0	1.9	2.1	0.0–12.0
Searching for dog	0.0	NA	NA	1.3	0.8	0.0-7.0	1.0	0.2	0.0–1.0	1.0	1.4	0.0–8.0

[1] Time between when hunters finished one pass and started another which usually involved hunters attempting to hunt with the wind.

Figure 1. The Surrogator® XL on a research field in Kiowa County, Kansas, 2010.

APPPENDICES

Appendix A: Hunter Information Survey given to participating bobwhite quail hunters during the Kansas bobwhite season from 2009-2011.

Hunter Information Survey

Name: Date:

Age: Gender:

How many years have you been bobwhite or pheasant hunting (counting current year)?

How many times a year do you go bobwhite or pheasant hunting?

If you saw any known banded Surrogator birds on your hunt on a scale of 1 to 10, with 1 being “tame” and 10 being “completely wild, how would you rate those birds?

Any other comments?

VITA

Jacob Martin Hagen

Candidate for the Degree of

Master of Science

Thesis: EFFECTIVENESS OF THE SURROGATOR® AT INCREASING NORTHERN BOBWHITE ABUNDANCE AND ENHANCING HUTNING

Major Field: WILDLIFE ECOLOGY AND MANAGEMENT

Biographical:

Education:

Completed the requirements for the Master of Science in Wildlife Ecology and Management at Oklahoma State University, Stillwater, Oklahoma in July, 2011.

Completed the requirements for the Bachelor of Science in Wildlife Biology at Murray State University in Murray, Kentucky in 2009.

Name: Jacob Martin Hagen Date of Degree: July, 2011

Institution: Oklahoma State University Location: Stillwater, Oklahoma

Title of Study: EFFECTIVENESS OF THE SURROGATOR® AT INCREASING NORTHERN BOBWHITE ABUNDANCE AND ENHANCING HUNTING

Pages in Study: 92 Candidate for the Degree of Master of Science

Major Field: Wildlife Ecology and Management

Scope and Method of Study: The main objectives of this study were to: (1) quantify in-surrogator survival of bobwhite chicks, (2) monitor post-release survival, habitat use, and dispersal, (3) and record rate at which surrogator bobwhite were harvested. In-surrogator survival was recorded by weekly monitoring the surrogator unit and recording mortality. Post-release data were obtained by attaching transmitters to a sample of surrogator bobwhites and using radiotelemtry to track the birds. Habitat use was measured using the Robel pole, Daubenmire frame, line intercept tape, and cone of vulnerability. Bobwhite harvest information was collected by monitoring hunters during the 2009–2011 bobwhite hunting seasons.

Findings and Conclusions: In-surrogator bobwhite survival was greater than reported for wild bobwhite chicks, resulting in more birds in the population. Post-release survival of surrogator bobwhites was lower than both wild bobwhites and other captive-release studies. Vegetation surveys at surrogator bobwhite locations revealed similar habitat use as wild bobwhites. Dispersal of surrogator bobwhites off release field was common and resulted in lost recreation to hunters. Surrogator bobwhites did supplement hunter harvest of wild bobwhites by an average of 31% per year, but a huntable population of strictly surrogator bobwhites was not established on the release field by that hunting season. Hunters rated surrogator bobwhites as similar to wild birds. Given these findings it appears surrogator bobwhite survival was too low to sustain a huntable population into the hunting season. Further without the presence of natural bobwhite populations hunter-covey encounters during the 2009–2011 bobwhite hunting seasons would have been rare. Some sportsmen and land managers may find use for the surrogator as a tool to supplement wild populations of bobwhites, though hunter opinion of benefits versus costs will vary.

ADVISER’S APPROVAL: Dr. Craig A. Davis