ABSTRACT

Northern bobwhite (Colinus virginianus) populations have declined over the past 5 decades in the southeastern United States due to changes in agricultural and forestry practices, increases in mammalian and avian predator populations, acceleration in fire suppression, and increases in human populations. Because of these declines, many landowners and plantation owners supplement wild bobwhite populations using captive pen-reared bobwhites. Restoration efforts using pen-reared bobwhites have often resulted in low returns and little recruitment. The use of captive wild-strain parent-reared bobwhite chicks has not been examined for supplementation or restoration purposes. I estimated survival of parent-reared bobwhites released at 5 weeks of age and return rates for pen-reared and parent-reared bobwhites. I also compared breeding season demographics among wild-strain fall release, parent-reared, and wild bobwhites. Only parent-reared chicks provided enough recaptures to estimate survival therefore no survival comparisons could be determined for the pen-reared. Wild and fall release bobwhites nested at similar rates and parent-reared and wild bobwhites had similar chick survival. My results show that parent-rearing of bobwhites in captivity show promise as a restoration technique.
INDEX WORDS: Northern bobwhite, *Colinus virginianus*, Georgia, pen-reared, parent-reared, wild-strain, survival, Brooks County, Tall Timbers, pens, fall release, rearing
REARING AND RELEASE TECHNIQUES FOR CAPTIVE
NORTHERN BOBWHITE QUAIL

by

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B. S., North Carolina State University, 2003

A Thesis Submitted to the Graduate Faculty of The University of Georgia in Partial Fulfillment
of the Requirements for the Degree

MASTER OF SCIENCE

ATHENS, GEORGIA

2008
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DEDICATION

I would like to dedicate this thesis to my wife, daughter, and parents who have supported me along the long road of pursuing a graduate degree. Katie, thank you for giving up time with your family to move with me to south Georgia and being understanding of the long hours in the field and away at school. Kylee, you have been the best daughter a father could ask for during these rough times. I look forward to spending many afternoons on the pond teaching you to enjoy and respect the outdoors as others have taught me. Thanks to my parents, Steve and Trudy, for giving me the desire and opportunity to pursue a career that will be exciting and rewarding in the wildlife field. I would also like to thank them for allowing me to live in the country and experience many eventful hours in the field and enjoying the “country” life.
ACKNOWLEDGEMENTS

I would like to thank the following people/organizations for support with the project: Pinion Point Plantation, Tall Timbers Research Station and Land Conservancy, and The University of Georgia's Warnell School of Forestry and Natural Resources. I would like to thank the many technicians and interns at Tall Timbers for their time and dedication to seeing the project through to the end. Bill Palmer, for giving me the opportunity to pursue a graduate degree and the many lessons of dealing with plantation owners. John Carroll, for the guidance and direction through coursework and graduate school. Karl V. Miller, for his guidance and great class to enhance my wildlife knowledge. I would especially like to thank the famous “Dr. Martin.” James provided aid in data analysis and proofed the many versions of my thesis. I would also like to thank Theron Terhune for his assistance with Program MARK and data analysis. Tall Timbers provided major funding, and additional funding was provided by Warnell School of Forestry and Natural Resources, McIntire-Stennis Project GEO 136, and Northeast Georgia Chapter of Quail Unlimited. All pen-reared chicks, parent-reared chicks, wild-strain foster parents, and wild northern bobwhites were captured and handled in compliance with requirements of UGA’s Institutional Animal Care and Use Committee (AUP # A3437-01).
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CHAPTER 1
INTRODUCTION AND LITERATURE REVIEW

INTRODUCTION

Over the past fifty years, Northern Bobwhite Quail (*Colinus virginianus*) (hereafter bobwhite) populations have declined precipitously throughout most of their native range (Brennan 1991, Church et al. 1993, Sauer et al. 2004). The Breeding Bird Survey (BBS) indicated a decline of 5.4% per year in the southeastern United States during 1980-2003 (Sauer et al. 2004). Many factors have been associated with the declines in bobwhite populations. Changes in forestry and agricultural practices have also led to decreasing occurrence of fallow and weedy crop fields that provide valuable bobwhite brooding habitat (Brennan 1991). Many fields have been converted to pine plantations that shade out the understory, eliminating valuable bobwhite foods and habitat (Stoddard 1931, Rosene 1969). Fire suppression has also led to decreases of quality bobwhite habitat (Brennan 1991). Increasing human populations have contributed to declines in early successional habitat (Brennan 1993b). Other factors may include increased mammal and avian predator populations (Rollins and Carroll 2001), increased use of pesticides in agriculture landscapes (Palmer et al. 1998), and the invasion of the non-native fire ant (*Solenopsis invicta*) (Brennan 1993a, Allen et al. 1995).

A number of management strategies have been attempted to reestablish bobwhites into areas that have been converted back into high quality bobwhite habitat. Recent research has demonstrated that translocation of bobwhites into suitable habitat is viable for areas that have
become isolated from other bobwhite populations. Terhune (2004) examined survival, reproduction, and population responses from resident and relocated bobwhites that were translocated prior to the breeding season and observed similar reproduction between the two groups. Jones (1999) examined home range, survival, reproduction, site fidelity, and population response of relocated bobwhites but had small sample sizes. Although translocation may be a viable technique, in some areas of its range, only limited numbers of wild bobwhites are available and expensive to obtain. In addition, translocations may be restricted due to state game laws.

Many studies have investigated the use of pen-reared bobwhites to restore declining bobwhite populations in areas that have been converted into quality habitat. Generally, these studies have demonstrated very low survival of released bobwhites and little to no recruitment as a result. Previous studies have examined characteristics of pen-reared bobwhites to help explain why they have lower survival and reproductive output than wild bobwhites. Proposed reasons for decreased survival of pen-reared birds includes decreased flight speeds and distances, poor utilization of escape cover, and social hierarchy differences (Perez et al. 2002). Others have suggested that long term breeding programs have led to reduced vigor, viability, growth rates, and fertility (Seal 1977). Releases of pen-reared bobwhites may also have negative impacts on native populations due to displacement of wild bobwhites, transmission of diseases to wild populations, possible increased wild bobwhite mortality to predation (Brennan 1991, Sisson et al. 2000), and dilution of the native gene pool (Landers et al. 1991).

Because released pen-birds have been ineffective for restoring populations due to low survival and poor long-term population recruitment, this technique is now used primarily for enhancing fall populations for greater harvest (DeVos and Speake 1995, Mueller et al. 1997).
Although many biologists consider using pen-reared bobwhites unjustified to augment local populations due to low survival (Buechner 1950, Ellsworth et al. 1988), few studies have examined different rearing techniques to increase survival and reproductive output.

Captive propagation of gamebirds also has been used to supplement low numbers in declining populations. With endangered species, such as the Masked Bobwhite Quail (*Colinus virginianus ridgwayi*), releasing captive-reared birds may be the only viable alternative (Gall et al. 2000). Propagation pens have been used successfully for rearing Attwater’s prairie chickens (*Tympanuchus cupido attwateri*), greater prairie chickens (*Tympanuchus cupido pinnatus*), gray partridge (*Perdix perdix*), and other Galliformes (Hess 2004). By allowing chicks to spend time in large pens, chicks can adapt to temperature variations, forage in their natural environment, and learn to select proper escape cover (Gall et al. 2000). Successful results in other species suggest that propagation pens may be a viable method for rearing northern bobwhite quail chicks.

The effects of parent-rearing in gray partridge, rock partridge (*Alectoris graeca*), hazel hen (*Bonasia bonasia*), and ptarmigan (*Lagopus mutus*) has also been studied (Thaler 1986). These studies examined a host of different effects that limits the effectiveness of using propagated birds to supplement fall populations or for restoring low density populations. Characteristics studied include anti-predator responses, nesting success, brooding success, and survival. Explanations for lower survival rates are associated with the anti-predator responses in captive reared gamebirds (Dowell 1992), which typically select for “tamer” birds for propagation. Also, rearing gamebirds without their parents does not provide opportunities to learn anti-predator responses early in life (Dowell 1992). For example, Dowell (1992) compared parent-reared chicks with gray partridge parents, parent-reared chicks with bantam parents, and intensively-reared chicks without parents and reported that chicks reared with species specific parents displayed
appropriate behaviors when predator models were introduced (Dowell 1992). Parent-reared chicks displayed correct “freezing” behaviors, whereas the chicks reared with the bantam hens and intensively-reared chicks displayed incorrect behaviors of running to cover and vigilant postures. Also, gray partridge that were parent-reared reacted more quickly to alarm responses than their intensively managed comparisons. Similarly, Brittas et al. (1992) found that pheasants reared with species specific foster parents had better clutch survival and brood survival than the machine-reared counterparts.

Past research with bobwhites is limited to propagation in commercial houses or in flight pens. Stoddard (1931) examined different rearing techniques by using bantam roosters and bobwhite cocks as foster parents. This may be the only attempt to study the effects rearing techniques on subsequent biology of released northern bobwhites. However, bobwhites reared under bantams miss some of the most important learned behaviors from their species specific parents. Some studies have shown many similarities of pen-reared bobwhites with native populations. Devos and Speake (1995) documented that pen-reared bobwhites interacted with wild bobwhites, mixed with wild coveys, and readily nested. Success of wild-strain stock has been seen with releases of first generation masked bobwhites bred from wild stock and “cross-fostered” with sterile Texas bobwhites (Backs 1982).

Important goals to strive for in the production of bobwhite chicks for restocking are instinctive behaviors, high survival rates, and the potential for long-term reproduction. Dowell (1992) suggested that altered behavior during the rearing process is a major obstacle to successful reintroduction and restocking. Rearing bobwhite chicks in a semi-natural environment should increase survival once released into the wild. Roseberry et al. (1987) found
that semi-wild and game-farm quail were similar in behavior and survival suggesting that rearing environment was an important factor in their survival.

Biologists agree that it is not sound management to release birds not capable of adapting to the habitat (Baumgartner 1944) and that cannot survive long enough to reproduce (Brakhage 1953). The goal of this project was to investigate factors that might improve bobwhite chick survival and perhaps increase reproductive potential. Efforts were focused on producing viable, high quality chicks with increased survival competence, rather than intensively managing for mass production or game-farming. The objectives of thesis research were to determine the effects of rearing on the survival and reproductive potential of bobwhite chicks released at early ages.

LITERATURE CITED


Hess, M. F. 2004. Flight characteristics of pen-reared and wild prairie-chickens and an evaluation of a greenhouse to rear prairie chickens. Thesis, Texas A&M University, College Station, TX.


CHAPTER 2
SURVIVAL OF PARENT-REARED NORTHERN BOBWHITE CHICKS RELEASED
INTO THE WILD

INTRODUCTION

Northern Bobwhite Quail (Colinus virginianus) (hereafter bobwhite) populations have declined throughout most of their range for longer than 50 years (Brennan 1991). Reports have documented declines as great as 66% (Sauer et al. 2004). These declines have prompted managers to identify alternative means to maintain high harvest rates, such as the release of pen-reared bobwhites. In some areas, habitat improvement projects have been successful at restoring early successional habitat. However, in some cases bobwhite populations have not responded. Isolated bobwhite populations have lower reproductive rates than larger populations (Terhune 2004). Successful support of these populations has been accomplished by translocations of wild bobwhites from larger, genetically diverse populations (Terhune 2004). Although translocation of wild bobwhites has been successful, there are potential problems with widespread application of the technique. For example, movement of wild bobwhites within or between states may not be permitted by state agencies. In addition, the difficulty and expense of obtaining enough birds may be impracticable.

Although used in hunting management for many decades, little success has been documented in using pen-reared bobwhites for restoration purposes. Recently claims that some individuals and companies have developed methods to produce wild bobwhite populations from captive birds, but in all these cases lack independent evidence that these systems are successful. Many of these new systems are modifications of methods historically used by game keepers for pheasant shooting on British estates (Hill and Robertson 1988, Robertson 1997). Pen-reared bobwhites typically have shown poor survival and little reproductive potential (Backs 1982). Possible explanations for this poor survival include decreased flight speeds and distances, poor utilization of escape cover, and aberrant and non-adaptive behaviors (Perez et al. 2002). Other
reasons may include loss of vigor, poor growth rates, and fertility issues from long-term breeding programs (Seal 1977). Additional concerns of using pen-reared bobwhites are that native genetic pools can be diluted (Landers et al. 1991), displacement of wild bobwhites, disease transmission, and possibly increased wild bobwhite mortality (Brennan 1991, Sisson et al. 2000).

Reduced survival of the pen-reared bobwhites (Dollar 1969, DeVos and Speake 1995, Perez et al. 2002) has been associated with increased avian and mammalian predation (DeVos and Speake 1995, Perez et al. 2002). However, the differential development of anti-predator responses with pen-reared and parent-reared bobwhites has not been investigated. Allowing adult bobwhites to undertake chick-rearing may reduce mortality and increase reproductive output of reintroduced birds. Parent-rearing has been examined in gray partridge (*Perdix perdix*), rock partridge (*Alectoris graeca*), hazen hen (*Tympanuchus cupido cupido*), and ptarmigan (*Lagopus muta*) (Thaler 1986). Studies with gray partridge suggested that nesting, brooding success, and overall survival were higher for parent-reared partridge chicks (Thaler 1986, Brittas et al. 1992, Dowell 1992). Parent-reared partridge also displayed correct anti-predator responses (Dowell 1992). We evaluated return rates and survival differences between typical pen-reared bobwhites and bobwhites reared with species specific parents in a semi-natural environment that were released into areas with known quality bobwhite habitat.

**METHODS**

**Study Area**

We conducted field research on Pinion Point Plantation (PP) in Brooks County in the Redhills Region of southern Georgia (Figure 2.1). Propagation pens were located at Tall Timbers Research Station (TTRS) about 49 km west of PP. The field site consisted of 1,821
hectares of a mix of habitat types of old field pine forests with low basal areas (3-9 BA m²/ha) (72%), rotational fallow fields (10%), longleaf pine (*Pinus palustris*) plantings (5%), and bald cypress (*Taxodium distichum*) dome wetlands (13%). Intensive management for bobwhites at PP includes prescribed burning, hardwood reduction, timber thinning, seasonal diskimg, drum-chopping, predator reduction, and supplemental feeding.

*Propagation Pens for Parent-reared Chicks*

Based on plans developed by Stoddard (1931), we constructed propagation pens that were trapezoidal-shaped (Figure 2.2). Houses were constructed on the smaller side of the trapezoid to provide shelter during heavy downpours. A pen height of 1.82 m allowed flight by chicks and easy access by observers. Tops of the pens consisted of netting to allow for chick acclimation to local weather. Sixteen pens were constructed for a capacity of 320 parent-reared chicks. Pens were enclosed by a snake fence and a solar-powered electric fence to exclude mammalian and reptilian predators. Pens were located away from human traffic and noise to minimize the opportunities for chicks to lose human avoidance instincts during rearing. Avian predators were observed commonly on top of pens and in neighboring trees, but we observed no mortality from these individuals.

*Rearing of Bobwhite Chicks*

All pen-reared chicks, parent-reared chicks, wild-strain foster parents, and wild northern bobwhites were captured and handled in compliance with requirements of UGA’s Institutional Animal Care and Use Committee (AUP # A3437-01). Wild-strain bobwhite eggs were obtained from deserted nests, hatched in an incubator, and reared in brooders. These birds were used as layers to obtain eggs for the study. The wild-strain bobwhite chicks were raised either in a normal communal brooder (pen-reared) or in a rearing operation with parental imprinting and
adoption (parent-reared). Adult foster bobwhites and eggs came from a local quail farm (Quail Call Farms, Tallahassee, Florida) and were hatched in a Model 1500 professional incubator (G. Q. F. Manufacturing Co., Savannah, Georgia).

Pen-reared chicks were removed from the incubator at hatching, placed into universal box type brooder pens (G. Q. F. Manufacturing Co., Savannah, Georgia), and raised to 35 days of age. The pen-reared chicks received commercial gamebird starter feed (Purina, St. Louis, Missouri) with free-standing waterers. At 2 weeks of age, proso millet (*Panicum miliaceum*) was mixed into the commercial feed. At 4 weeks of age, grain sorghum (*Sorghum bicolor*) was mixed into commercial feed. Sorghum was introduced to have similar foods at the release areas. Chicks could also eat insects and weed seeds found in pens. Daily care was structured to minimize human interactions and imprinting with chicks. Pen-reared chicks were weighed at 12 days of age and numbered bands were attached to their wing patagium (National Band and Tag Co., Newport, Kentucky). At 21-35 days of age, brooder heaters were reduced to prepare chicks for natural temperatures.

Parent-reared chicks were taken from the incubators after hatching and introduced to a wild-strain, adult female bobwhite foster parent. Foster parents were placed in boxes for 10-15 minutes to reduce stress, after which 20 chicks were added behind a piece of clear plastic. If the foster bird remained calm, the divider was removed so chicks and adult birds came into contact and began the imprinting and adoption process. Observers watched through a small hole in the boxes to ensure adoption occurred. Brood rejection included pecking of the chicks, running in circles, or prolonged agitation of the hen. If the foster bird rejected the brood, the hen was removed to reduce injury to the chicks. Successfully adopted parents brooded chicks and vocalized with the chicks. Adopted chicks and foster birds were held overnight to strengthen the
bond between the foster parent and chicks (Stoddard 1931). The following morning, they were taken to the propagation pens where they remained for 35 days. There was no supplemental heating inside pens. Chicks were fed, watered, and banded as described for the pen-reared birds. At approximately 35 days of age, chicks were captured and placed into small release boxes for transport to release locations. To equalize samples, pen-reared chick broods were matched to the size of parent-reared broods and were released at randomly selected and paired release sites.

**Summer Releases**

During 2005 and 2006, we released broods during 3 monthly periods. In 2005, birds were released in July, August, and September. In 2006, birds were released in July, August, and October. Release locations were selected based on known use of the area by wild bobwhite broods, then sites were recorded with global positioning systems (Trimble XT, Sunnyvale, California) for importing into ArcGIS 9.2 (ESRI, Redlands, California, USA). Release locations were located ≥200 meters apart to avoid brood mixing of parent-reared and pen-reared chicks. The actual release site for each group was randomly selected and paired for each group (pen and parent-reared). Before the release, grain sorghum was broadcast around the release location and a recording of a bobwhite hen call was played over a speaker to attract males or possibly females to the area to facilitate mixing with wild bobwhites for brood amalgamation (Faircloth et al. 2005). The birds were left with the release boxes which were left at release sites until the following day to minimize chick disturbance and provide shelter if needed.

**Post-release Monitoring**

Re-trapping sessions were conducted in October and March following releases of the parent-reared and pen-reared bobwhites to minimize disturbance to hunting activities. October trapping sessions were approximately 2 weeks and the March trapping periods were
approximately 4 weeks long. Bobwhites were captured using walk-in funnel traps baited with commercial grain sorghum (Stoddard 1931). Birds were aged, sexed, weighed to the nearest gram, and banded (if weighing ≥ 120 g) with an aluminum legband (#7; National Band and Tag Co., Newport, Kentucky). All birds were released at trapped locations.

Return rates were used to compare potential recruitment from parent-reared chicks and pen-reared chicks. Numbers of chicks captured were used to assess which method returned the most individuals during the fall hunting season or for carry over for the next breeding season. Return rates were calculated for each release during 2005 and 2006 for both parent-reared and pen-reared bobwhites.

*Parent-reared survival estimates*

Mark-recapture methods are used extensively in many wildlife studies (Otis et al. 1978, Cormack 1992). We used program MARK (White and Burnham 1999) to estimate abundances and survival of parent-reared bobwhites because previous research showed its value in assessing survival and covariates of bobwhites (Palmer and Wellendorf 2007, Terhune et al. 2007). We used the Burnham model incorporating live and dead recoveries (Palmer and Wellendorf 2007, Terhune et al. 2007) to calculate survival ($\phi$), recapture ($\rho$), and recovery ($r$) estimates (White and Burnham 1999). We used 5 intervals (LDLDLDLDLD) where the first three intervals were release periods and the following 2 periods were October and March trapping sessions, respectively. Each interval designated as L included the live trapping encounters, and D interval included dead recoveries or encounters outside the designated trapping sessions. We defined interval lengths from July to August, August to September, September to October, October to October, and October to March for both 2005 and 2006. Interval lengths in days for 2005 releases were 39, 39, 15, and 133, respectively, and interval lengths in days for 2006 releases
were 39, 39, 15, and 128, respectively. We also modeled year as a covariant to assess variation in annual survival.

We imposed several constraints prior to the analysis: recapture probabilities ($\rho$) for periods 1 and 2 were constrained to 0 because recapture (no trapping occurred) was not possible during these periods; recovery periods ($r$) 1, 2, and 3 were constrained to 0 because these were designated release periods and no harvest (recovery) occurred rendering a 0 probability of recovery; and we additionally constrained site fidelity ($F$) to 0.99, because radio-telemetry revealed that movement off the study site was minimal. The site fidelity observation was corroborated by harvest records and physical barriers occurring outside the immediate study site.

We used information-theoretic approaches to evaluate our set biologically derived candidate models (Burnham and Anderson 1998, Anderson et al. 2000). The best model of the candidate set was determined by Akaike’s Information Criterion adjusted for small sample size bias and overdispersion (QAIC$_c$) (Burnham and Anderson 1998). We used QAIC$_c$ to compare the set of candidate models and considered the best model to have the lowest QAIC$_c$ value (Burnham and Anderson 1998). To increase the precision of our estimates and account for model uncertainty, we model averaged parameter estimates over all candidate models that included the parameter of interest to have more precise survival estimates (Burnham and Anderson 1998, White and Burnham 1999).

Costs of producing parent-reared chicks

Pen-reared bobwhites are propagated across the entire southeastern United States and for comparative purposes we calculated costs of parent-rearing compared to the techniques commonly used now. These birds are marketed and sold to hunters, landowners, or plantation owners. Generally, there are 2 methods in which these bobwhites are reared. The first involves
the use of closed houses. These bobwhites are raised in gas-heated brooders to 2 weeks of age and released from brooder enclosures into separated sections in houses. Bobwhites remain in the houses until 10 to 12 weeks of age. Bobwhites reared using these systems are sold commercially from $1.85 to $3.00 per bird (S. Cass, personal communication).

The second method involves the same rearing as above, but the chicks are released from the houses into flight pens at 5 to 8 weeks of age. Flight pens are constructed of mesh netting on the sides and top. The bottom of the sides of the flight pens are reinforced with boards to prevent mammals and other predators from disturbing bobwhites inside pens. These birds are readily acclimated to environmental conditions, but have lower survival percentages inside pens. Bobwhites reared using these methods are sold commercially from $3.00 to $5.00 per bird (D. Poole, personal communication).

We calculated the costs of pen construction, maintenance hours per season, adoption hours per season, feed and medication costs, and allowed an 8% overhead. The cost of the incubator was not included since the equipment was provided from Tall Timbers Research Station. Bobwhite eggs were also provided at no cost for the project. Calculating the total of these costs allowed for a break-even amount for land managers or owners to determine if the method is feasible from their budgets and goals. These cost calculations are simplistic for the purposes of the project and do not include such factors as discount rates, inflation, or time value of money. For the analysis, we used the second year production of chicks to provide costs.

RESULTS

Over the 2 year study, we released 595 chicks for each treatment. Releases in 2005 for parent-reared and pen-reared bobwhites were 58, 45, and 50, for July, September, and August,
respectively. Releases in 2006 for parent-reared and pen-reared bobwhites were 165, 96, and 181 for July, September, and October, respectively. Chicks release weights were significantly different between parent-reared and pen-reared bobwhites. Parent-reared and pen-reared chicks weighed 60.7 g (59.4-62.0, 95% CI) and 74.3 g (73.0-75.5, 95% CI), respectively. We recaptured a total of 68 parent-reared chicks in October, 35 were recaptured in March, and 3 were recovered from hunting. Of the pen-reared chicks, a total of 1 was captured in October, 5 were recaptured in March, and 1 was recovered from hunting.

Parent-reared and pen-reared bobwhite releases during 2005 returned an average of 9.5% (range from 1.7 to 20.0) and 0.0% (n=0) to the fall trapping session in October, respectively, and an average 3.5% (range 0.0 to 6.0) and 2.0% (range 0.0 to 6.0) to the following spring trapping session in March, respectively (Table 2.1). Parent-reared and pen-reared bobwhite releases that occurred during 2006 returned an average 11.4% (range 0.0 to 24.9) and 0.2% (range 0.0 to 0.6) to the fall trapping session in October, respectively, and an average 7.7% (range 1.8 to 13.5) and 0.5% (range 0.0 to 1.0) to the spring trapping session in March, respectively.

There were no differences in distances from release to recapture locations for any of the treatment-year combinations. Average distance from the summer release sites to March recapture sites for pen-reared birds was 584 m (n=3, SE=134.6) and 478 m (n=2, SE=100.3), during 2006 and 2007, respectively. Average distances from the summer release sites to March capture sites for parent-reared birds was 588 m (n=5, SE=167.5) and 374 m (n=30, SE=54.8) during 2006 and 2007, respectively. Movements off the study area were minimal due to a large watershed and river corridors surrounding the study site. Harvest records on adjacent areas returned no study animals.
**Parent-reared chick survival**

We could not compare capture survival estimates between treatments because of small recapture sample sizes (n=6) of pen-reared bobwhites that precluded the analysis. Parent-reared bobwhites had sufficient recaptures (n=91) to estimate survival, recapture, and recovery probabilities. The candidate models were ranked according the QAICc values (lowest QAICc values were best models). The model that minimized QAICc \((\phi, p, r, f)\) included the parameters survival, recapture, recovery, and site fidelity (fixed) being constant (Table 2.2). Model weight for the QAICc lowest model \((w_f=0.41)\) provided evidence that this was the top model. The second best fitting model \((\phi_{\text{year}}, p, r, f)\) included year dependence for survival, but all other parameters were constant. Model weight for this model was close to the top model \((w_f=0.30)\) and was 1.3 times less likely than the model that minimized QAICc. The third best fitting model \((\phi_{\text{year}}, p_{\text{year}}, r_{\text{year}}, f)\) had a model weight \((w_f=0.18)\) that was 2.2 less likely than the top model. The last model \((\phi_{\text{year}}, p_{\text{year}}, r, f)\) had a model weight \((w_f=0.11)\) and was 3.7 times less likely than the top model.

Model averaged estimates of survival were generated from the 4 models of interest to obtain more precise parameter estimates (Table 2.3). Survival estimates for parent-reared bobwhites released in July, August, and September of 2005 until the fall trapping session were 24.7% (3.3-56.5%, 95% CI), 44.4% (13.7-71.8%, 95% CI), and 79.8% (57.8-91.2%, 95% CI), respectively (Table 2.4). Survival estimates for parent-reared bobwhites released in July, August, and September of 2006 until the fall trapping session were 42.6% (30.8-53.9%, 95% CI), 60.9% (50.5-69.8%, 95% CI), and 87.1% (82.7-90.5%, 95% CI), respectively (Table 2.4).

Survival estimates for parent-reared bobwhites released in July, August, and September of 2005 until the following spring trapping session were 3.5% (0.0-25.3%, 95% CI), 6.2% (0.1-
32.1%, 95% CI), and 11.1% (0.5-40.8%, 95% CI), respectively (Table 2.5). Survival estimates for parent-reared bobwhites released in July, August, and September of 2006 until the following spring trapping session were 12.8% (5.9-22.6%, 95% CI), 18.3% (9.6-29.2%, 95% CI), and 26.2% (15.7-37.9%, 95% CI), respectively (Table 2.5). Over-winter survival (October to March) estimates of parent-reared bobwhites was 14.0% (0.8-44.8%, 95% CI) and 30.1% (19.0-41.9%, 95% CI) for 2005 and 2006 releases, respectively (Table 2.5).

*Costs of propagation of parent-reared chicks*

The largest capital investment for the project was construction of the parent-reared chick facility estimated at $7,000 (man-hours were not considered, part of the project). Other capital investments included watering lids and electric fencing equipment which was $236. Pen maintenance, feeding, watering, and chick capture was estimated to 150 hours per season. Adoption periods was estimated to 36 hours per season (these periods includes the chick adoption to wild-strain bobwhites). The costs per hour were calculated using a wage of $10 per hour. The total labor hour costs for the pens totaled to $1,860. Overhead costs of the project were estimated using 8% of total costs and totaled to $250.

Production of roughly 441 parent-reared chicks would cost $9,571 in the first year. The cost per bird in this case comes to $21.70. This number appears to be somewhat higher than the two commonly used methods of pen-reared bobwhites ($1.85 to $5.00). However, the cost drastically decreases if extended from year 1 to 5. The costs per bobwhite from year 1 to 5 are $21.70, $13.73, $11.07, $9.74, and $8.94, respectively. Costs projected to year 10 would reduce the costs to $7.34 per bird.
DISCUSSION

Returns from our over-winter period suggest that recoveries of pen-reared bobwhite released at 5 weeks of age are minimal to none. Roseberry et al. (1987) reported return rates of 10% for 1st generation bobwhites and 8% for game-farm bobwhites. However, their returns were only from mid-November until late-February and sample sizes (n=223) were lower. Many studies have reported harvest returns from November to March of pen-reared bobwhites of less than 1% (Speake 1967, Dollar 1969). Our results support those of previous studies suggesting that releasing pen-reared bobwhites at early ages is not recommended for any reason other than additional harvest.

Movements of parent-reared and pen-reared bobwhites were similar to other studies. Mueller (1984) reported movement distances of 0.51 kilometers (510 m). The study was conducted in Florida and applies more directly to our study since habitat types and predator communities were very similar between study areas. In Illinois, bobwhites moved distances of 124 m and 157 m for 1st generation and game farm bobwhites, respectively (Roseberry et al. 1987). Buechner et al. (1950) reported larger movements of 1.45 miles (2333 m) in Oklahoma. However, this study had relatively small sample sizes and different habitat types. Our observed movement distances were within the range of previous studies and we believe that released birds remained on the study site.

Although we could not compare survival estimates, we believe that the biological significance of releasing parent-reared bobwhites was adequate. Because very few pen-reared chicks were recovered, and showed no evidence of dispersing, we assumed a much lower survival than their parent-reared counterpart. Over-winter survival estimates of the parent-reared bobwhites were higher than previous pen-reared bobwhite reports of over-winter survival.
Pierce (1951) reported pen-reared over-winter survival of 7% from autumn to spring. Similarly, Devos and Speake (1993) reported 20% survival of pen-reared bobwhites to April. Parent-reared chicks may have displayed correct anti-predator, social, and brooding behaviors once released from their rearing pens resulting in higher survival. Imprinting on a parent is critical to future expression of bird behaviors (Dowell 1992) but is not part of any commercial release program. Rearing in the natural environment with the parents also may have increased chick survival. Roseberry et al. (1987) also found that bobwhites reared in the natural environment had higher survival rates and was an important factor in their survival. Roseberry et al. (1987) found that bobwhites close to wild genetics also had higher survival rates than bobwhites from typical pen-reared operations with many generations in captivity. Rearing with a parent and in the semi-natural environment aided survival of gray partridge (Dowell 1992). However, Perez et al. (2002) found no difference in wild-strain (F1) genetics compared to game farm bobwhites in the Rio Grande Plains of Texas.

Survival estimates for parent-reared bobwhites released in 2006 were higher than 2005. Rainfall amounts were greater during summer months from tropical storms and hurricanes in 2005, which likely reduced chick survival. Evening thunderstorms were also more prevalent in the 2005 season than the 2006 season which may have reduce survival during the period. Other activities on the property could have impacted the survival of these chicks. Prescribed burning and thinning of timber stands limited residual cover for the fall of 2005. Intensive dragging of steel tracks over burned areas to increase soil disturbance resulted in thin cover and possibly attributed to increased mortality of the winter period. The second year had much less rainfall and habitat conditions had improved from the following growing season. Prescribed burning
was conducted under proper management guidelines and other habitat manipulations were held to a minimum on the study areas.

Wild bobwhites could have played a role in the increased survival of released birds. Adoption of chicks and mixing of broods is seen readily in bobwhites (Faircloth et al. 2005). These adoptions could have influenced the survival of the parent-reared chicks. During the trapping sessions, parent-reared chicks were caught with wild bobwhites on the property whereas the pen-reared bobwhites were more solitary and often were not with wild bobwhites. Research on the mechanisms influencing mixing of reared and wild birds may provide insight on failure of pen-reared birds to survive in the wild.

Extrapolating our results, we could estimate the recruitment of parent-reared bobwhites to the spring breeding season that might be done in a management context. Assuming that 1,000 parent-reared bobwhites were released in October (from 2006 estimates), the number of bobwhites that would survive to the breeding season would be 300 birds. Assuming equal sex rations, the released population would provide 150 bobwhite hens for recruitment in the breeding population. Thus, parent-reared bobwhites released on a site would have greater potential to make it to the breeding season and possibly increase recruitment in the following fall population.

The production of parent-reared chicks is more costly than pen-reared bobwhites. The time spent in the process of imprinting, parent adoption, and construction is expensive for any landowner but the returns from these individuals may be much higher and increase the reproductive potential of their investment. When bobwhites are released at 5 weeks of age, very few returns can be expected from the pen-reared individuals. When considering the return, the parent-reared chicks appears to be a better option if releases are going to occur in the summer or early fall to provide a bird capable of reproducing in the next breeding season. If costs are
spread out over a 5 year timeline, the cost per bird is substantially reduced to $8.94 by year 5. If
the simulation is run out to 10 years, the cost per bird is reduced to $7.34. If we combine this
with the hypothetical above, then we have a cost of $7,340 to produce 300 hens in the spring
population, resulting in a per bird cost of $24.47. The total costs we found are not significantly
higher than the costs of other wild-strain bobwhites sold in the Southeast and should be
considered in restoration efforts or for improved harvest potential.

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Dollar, W. M. 1969. Movements, survival, and behavior patterns of pen-raised bobwhite quail (*Colinus virginianus*) on an established management area. Thesis, Auburn University, Auburn, AL.


Table 2.1. The percent return rates for parent-reared and pen-reared bobwhites released during 2005 and 2006 to the following trapping periods on Pinion Point Plantation. The dates from year to year were within one week to have similar survival periods for comparison.

<table>
<thead>
<tr>
<th>Release Date</th>
<th># Released</th>
<th>Parent-reared Bobwhites</th>
<th>Pen-reared Bobwhites</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Oct. % Return</td>
<td>Mar. % Return</td>
</tr>
<tr>
<td>15 July 2005</td>
<td>58</td>
<td>1.7</td>
<td>0.0</td>
</tr>
<tr>
<td>22 August 2005</td>
<td>45</td>
<td>6.7</td>
<td>4.4</td>
</tr>
<tr>
<td>29 September 2005</td>
<td>50</td>
<td>20.0</td>
<td>6.0</td>
</tr>
<tr>
<td>17 July 2006</td>
<td>165</td>
<td>0.0</td>
<td>1.8</td>
</tr>
<tr>
<td>26 August 2006</td>
<td>96</td>
<td>9.4</td>
<td>13.5</td>
</tr>
<tr>
<td>05 October 2006</td>
<td>181</td>
<td>24.9</td>
<td>7.7</td>
</tr>
</tbody>
</table>
Table 2.2. Survival ($\phi$), recapture ($p$), recovery ($r$), and fidelity ($f$) models for parent-reared bobwhite chicks tested for year effect (year) at Pinion Point Plantation in South Georgia during 2005-2007.

<table>
<thead>
<tr>
<th>Models</th>
<th>QAICc</th>
<th>$\Delta$QAICc</th>
<th>Parameters</th>
<th>QDeviance</th>
<th>$w_i$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\phi.p.r.f.$</td>
<td>278.494</td>
<td>0.00</td>
<td>3</td>
<td>272.460</td>
<td>0.40883</td>
</tr>
<tr>
<td>$\phi_{\text{year}}p.r.f.$</td>
<td>279.101</td>
<td>0.6074</td>
<td>4</td>
<td>271.044</td>
<td>0.30175</td>
</tr>
<tr>
<td>$\phi_{\text{year}}r_{\text{year}}f.$</td>
<td>280.150</td>
<td>1.6557</td>
<td>6</td>
<td>268.029</td>
<td>0.17865</td>
</tr>
<tr>
<td>$\phi_{\text{year}}r_{\text{year}}f.$</td>
<td>281.106</td>
<td>2.6116</td>
<td>5</td>
<td>271.019</td>
<td>0.11077</td>
</tr>
</tbody>
</table>
Table 2.3. Model-averaged estimates and unconditional standard errors and confidence intervals of the effects on the parent-reared chick survival at Pinion Point Plantation for 2005-2007 (see Table 2.2 for descriptions of the models).

<table>
<thead>
<tr>
<th></th>
<th>β-estimate</th>
<th>SE</th>
<th>LCI</th>
<th>UCI</th>
</tr>
</thead>
<tbody>
<tr>
<td>intercept</td>
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<td>4.3628</td>
<td>5.0099</td>
</tr>
<tr>
<td>year</td>
<td>-0.4963</td>
<td>0.2944</td>
<td>-1.0733</td>
<td>0.0806</td>
</tr>
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</table>
Table 2.4. Parent-reared bobwhite modeled averaged survival estimates over the periods of release to fall trapping sessions with the 95% CI for the releases during 2005 and 2006.

<table>
<thead>
<tr>
<th>Periods</th>
<th>Year</th>
<th>Estimate</th>
<th>LCI</th>
<th>UCI</th>
</tr>
</thead>
<tbody>
<tr>
<td>July-October</td>
<td>2005</td>
<td>0.2471</td>
<td>0.0333</td>
<td>0.5652</td>
</tr>
<tr>
<td></td>
<td>2006</td>
<td>0.4259</td>
<td>0.3080</td>
<td>0.5388</td>
</tr>
<tr>
<td>August-October</td>
<td>2005</td>
<td>0.4441</td>
<td>0.1386</td>
<td>0.7180</td>
</tr>
<tr>
<td></td>
<td>2006</td>
<td>0.6092</td>
<td>0.5047</td>
<td>0.6983</td>
</tr>
<tr>
<td>September-October</td>
<td>2005</td>
<td>0.7981</td>
<td>0.5776</td>
<td>0.9121</td>
</tr>
<tr>
<td></td>
<td>2006</td>
<td>0.8714</td>
<td>0.8270</td>
<td>0.9051</td>
</tr>
</tbody>
</table>
Table 2.5. Parent-reared bobwhite modeled averaged survival estimates over the periods of release to spring trapping sessions with the 95% CI for the releases during 2005 and 2006.

<table>
<thead>
<tr>
<th>Periods</th>
<th>Year</th>
<th>Estimate</th>
<th>LCI</th>
<th>UCI</th>
</tr>
</thead>
<tbody>
<tr>
<td>July-March</td>
<td>2005</td>
<td>0.0345</td>
<td>0.0003</td>
<td>0.2530</td>
</tr>
<tr>
<td></td>
<td>2006</td>
<td>0.1280</td>
<td>0.0586</td>
<td>0.2255</td>
</tr>
<tr>
<td>August-March</td>
<td>2005</td>
<td>0.0620</td>
<td>0.0011</td>
<td>0.3214</td>
</tr>
<tr>
<td></td>
<td>2006</td>
<td>0.1831</td>
<td>0.0961</td>
<td>0.2923</td>
</tr>
<tr>
<td>September-March</td>
<td>2005</td>
<td>0.1114</td>
<td>0.0048</td>
<td>0.4083</td>
</tr>
<tr>
<td></td>
<td>2006</td>
<td>0.2619</td>
<td>0.1574</td>
<td>0.3788</td>
</tr>
<tr>
<td>October-March</td>
<td>2005</td>
<td>0.1396</td>
<td>0.0083</td>
<td>0.4476</td>
</tr>
<tr>
<td></td>
<td>2006</td>
<td>0.3005</td>
<td>0.1904</td>
<td>0.4185</td>
</tr>
</tbody>
</table>
Figure 2.1. Study site location at Pinion Point Plantation in Brooks County, Georgia.
Figure 2.2. Design of parent-reared pens for the experiment was based on the trapezoidal-shape from previous studies by Stoddard (1931).
CHAPTER 3

REPRODUCTIVE DEMOGRAPHICS OF RELEASED BOBWHITE QUAIL:

EFFECTS OF REARING METHOD

INTRODUCTION

Northern Bobwhite Quail (*Colinus virginianus*) (hereafter, bobwhite) populations have declined throughout most of their native range since the mid-1900s. In the Southeast during 1966-1999, bobwhite populations have declined an estimated 66% (Sauer et al. 2004) due to loss of early of successional habitat, increased predators numbers (Rollins and Carroll 2001), suburban expansion, and changing forestry practices (Brennan 1991). The decline of this once prominent gamebird has drawn significant attention because it is considered an indicator of quality early successional habitat important for many other early successional songbirds.

Many state agencies have developed plans to keep populations from declining further and conservation programs to help landowners create or reestablish quality early successional habitat. In some areas, these management plans have led to increases in local bobwhite populations where sufficient breeding stock existed. However, in some areas bobwhite populations are near local extinction and despite restoration of quality bobwhite habitat, populations have failed to increase. In these areas, alternative management strategies are needed to restore bobwhites populations. Translocation of wild bobwhites has proven successful (Terhune 2004) and relocated bobwhites reproduce similar to resident bobwhites. However, wild bobwhites needed for these translocations may be difficult to obtain due to low populations and may be fairly expensive. In addition, this technique may not be permitted by some state agencies.

Previously, use of pen-reared bobwhites has not proven successful. However, the rearing method and social characteristics of pen-reared bobwhites may have an effect on subsequent survival and reproduction of released birds. Studies of Masked Bobwhite Quail (*Colinus virginianus ridgwayi*) using wild stock and reared chicks with wild “foster” parents and released back into the wild was at least initially successful (Backs 1982). These birds were reared in their
semi-natural environment with parental care to improve their natural characteristics. This
technique also reduced imprinting on humans.

Failure of pen-reared bobwhites to survive and reproduce in the wild might be due to a
number of confounding factors including behavior, imprinting, and genetics due to inbreeding
and selection in captivity. Perez et al. (2002) documented that lower survival of pen-reared
bobwhites resulted from decreased flight speeds, poor utilization of escape cover, and aberrant
and non-adaptive behaviors. Similarly, others have suggested that long-term breeding programs
have led to reduced viability, growth rates, vigor, and fertility (Seal 1977). Releases of pen-
reared bobwhites may possibly displace wild bobwhites, transmit diseases to wild populations,
and increase mortality to wild bobwhite populations (Brennan 1991, Sisson et al. 2000). To
further evaluate the use of pen-reared bobwhites, we compared the reproductive effort of the
parent-reared and fall release bobwhites released into the wild. We also compared the released
birds with resident, wild bobwhites on Pinion Point Plantation in southern Georgia.

METHODS

Study Area

We conducted field research on Pinion Point Plantation (PP) in Brooks County in the
Redhills Region of southern Georgia (Figure 3.1). Propagation pens were located at Tall
Timbers Research Station (TTRS) about 49 km west of PP. The field site consists of 1,821
hectares consisting of a mix of habitat types of old field pine forests with low basal areas (3-9
m²/ha) (72%), rotational fallow fields (10%), longleaf pine (Pinus palustris) plantings (5%), and
cypress (Taxodium) dome wetlands (13%). Intensive management for bobwhites at PP includes
prescribed burning, hardwood reduction, timber thinning, seasonal disking, drum-chopping, predator reduction, and supplemental feeding.

Propagation Pens for Parent-reared Chicks

Based on work by Stoddard (1931), propagation pens were trapezoidal-shaped (Figure 2.2). Houses were constructed on the smaller side of the trapezoid to provide shelter during heavy downpours. A pen height of 1.82 m allowed flight by chicks and easy access by observers. Tops of the pens consisted of netting to allow for chick acclimation to local weather. Sixteen pens were constructed for a capacity of 320 parent-reared chicks. Pens were enclosed by a snake fence and a solar-powered electric fence to exclude mammalian predators. Pens were located away from human traffic and noise to minimize the opportunities for chicks to lose human avoidance instincts during rearing. Avian predators were observed commonly on top of pens and in neighboring trees, but we observed no mortality from these individuals.

Rearing of Bobwhite Chicks

All pen-reared chicks, parent-reared chicks, wild-strain foster parents, and wild northern bobwhites were captured and handled in compliance with requirements of UGA’s Institutional Animal Care and Use Committee (AUP # A3437-01). Wild-strain bobwhite eggs were obtained from deserted nests, hatched in an incubator, and reared in brooders. These birds were used as layers to obtain eggs for the study. The wild-strain bobwhite chicks were raised either in a normal communal brooder (pen-reared) or in a rearing operation with parental imprinting and adoption (parent-reared). Adult foster bobwhites and eggs came from a local quail farm (Quail Call Farms, Tallahassee, Florida) and were hatched in a Model 1500 professional incubator (G. Q. F. Manufacturing Co., Savannah, Georgia).
Pen-reared chicks were removed from the incubator at hatching, placed into universal box type brooder pens (G. Q. F. Manufacturing Co., Savannah, Georgia), and raised to 35 days of age. The pen-reared chicks received commercial gamebird starter feed (Purina, St. Louis, Missouri) with free-standing waterers. At 2 weeks of age, proso millet (Panicum miliaceum) was mixed into the commercial feed. At 4 weeks of age, grain sorghum (Sorghum bicolor) was mixed into commercial feed. Sorghum was introduced to have similar foods at the release areas. Chicks could also eat insects and weed seeds found in pens. Daily care was structured to minimize human interactions and imprinting with chicks. Pen-reared chicks were weighed at 12 days of age and numbered bands were attached to their wing patagium (National Band and Tag Co., Newport, Kentucky). At 21-35 days of age, brooder heaters were reduced to prepare chicks for natural temperatures.

Parent-reared chicks were taken from the incubators after hatching and introduced to a wild-strain, adult female bobwhite foster parent. Foster parents were placed in boxes for 10-15 minutes to reduce stress, after which 20 chicks were added behind a piece of clear plastic. If the foster bird remained calm, the divider was removed so chicks and adult birds came into contact and began the imprinting and adoption process. Observers watched through a small hole in the boxes to ensure adoption occurred. Brood rejection included pecking of the chicks, running in circles, or prolonged agitation of the hen. When successful, the foster parents brooded and vocalized with chicks. If the foster bird rejected the brood, the hen was removed to reduce injury to the chicks. Adopted chicks and foster birds were held to strengthen the bond between the foster parent and chicks (Stoddard 1931). The following morning, they were taken to the propagation pens where they remained for 35 days. There was no supplemental heating inside pens. Chicks were fed, watered, and banded as described for the pen-reared birds. At
approximately 35 days of age, chicks were captured and placed into small release boxes for transport to release locations. To equalize samples, pen-reared chick broods were matched to the size of parent-reared broods and were released at randomly selected and paired release sites.

**Summer Releases**

Three releases each were conducted during 2005 and 2006. In 2005, birds were released in July, August, and September. In 2006, birds were released in July, August, and October. Release locations were selected based on high use of wild bobwhite broods in quality habitat and sites were recorded with global positioning systems (Trimble XT, Sunnyvale, California) for importing into ArcGIS 9.2 (ESRI, Redlands, California). Release locations were located approximately 200 meters apart to avoid brood mixing of parent-reared and pen-reared chicks. Release locations were randomly selected and paired for each group (pen and parent-reared). Before the release, grain sorghum was broadcast around the release location and a recording of a bobwhite hen call was played over a speaker to attract males or possibly females to the area to facilitate mixing with other wild bobwhites for brood amalgamation (Faircloth et al. 2005). Release boxes were left at release sites until the following day to minimize chick disturbance and provide shelter.

**Fall Release of Wild-strain Bobwhites**

Fall release bobwhites were reared in houses with gas heat for 5 weeks. Bobwhites were slowly introduced into flight pens planted with grain sorghum over the following 2 weeks. Houses were left open for protection in heavy rains. Fall release bobwhites were fed and watered similarly as described for the parent-reared birds. After a 2 week period, birds were excluded from houses to be reared in the semi-natural environment. Daily care was structured to minimize human interactions with chicks and reduce imprinting. Fall release bobwhites were
purchased from a local quail farm (Quail Call Farms, Tallahassee, FL) and released at 10 weeks of age in 2005 and 2006. Released occurred during the first week of October. Fall release bobwhites were used to supplement wild bobwhites on the property for increased harvest. Birds were captured, banded, and placed in small release boxes the previous evening. Observers scattered grain sorghum throughout the area to prevent birds from leaving the immediate area. On the morning of the release, birds were transported to release locations (grain sorghum patches) and doors of the boxes were opened and observers immediately left the area. This method of release allowed birds to acclimate to their surroundings before the hunting season began. Birds were flushed by dogs before the season to aid in flight response for more natural flight characteristics. All wild-strain fall release bobwhites were banded with number 7 aluminum legbands (National Band and Tag Co.) to monitor harvest on these release areas.

Post-release Monitoring

Trapping sessions were conducted in October and March following releases of the parent-reared, pen-reared, fall release, and wild bobwhites to minimize disturbance to hunting activities. October trapping sessions were approximately 2 weeks and the March trapping periods were approximately 4 weeks long. Bobwhites were captured using walk-in funnel traps baited with commercial grain sorghum (Stoddard 1931). Birds were aged, sexed, weighed to the nearest gram, and banded (if weighing ≥ 120 g) with an aluminum legband (#7; National Band and Tag Co., Newport, Kentucky). Any captured individuals from the released populations weighing ≥ 140 g received a 6 g (150-151 MHz), pendant-style, radio-transmitter (American Wildlife Enterprises, Monticello, Florida 32312) in the March trapping session for breeding season demographics. All birds were released at trapped locations.
Parent-reared, pen-reared, fall release, and wild bobwhites that received radio-transmitters were monitored throughout the breeding season. Observers used radio receivers (Advanced Telemetry Systems, Inc., Isanti, Minnesota, USA) and 3-element folding Yagi antennas to home locations for daily tracking. Daily monitoring began in mid-April to determine breeding season demographics of these individuals and continued through late September. After this time period, weekly monitoring began until the next breeding season. During the nesting season, birds were monitored ≥ 5 days a week. If bobwhites were located in the same location via homing for a 2 day period, the potential nesting site would be flagged. The nest would be confirmed by the second day. Nest clutch sizes were measured by allowing the nesting bobwhites to leave the nests in the evenings when the birds left the nest to forage. No birds were flushed off nests to obtain clutch size counts to eliminate nest abandonment.

**Summer captures of wild, parent-reared, and fall release bobwhite chicks**

During the summer of 2006 and 2007, early morning brood captures were conducted on radio-collared bobwhites with broods. Once broods reached 8 days of age, chicks were captured using techniques described by Smith et al. (2003). Capture panels were composed of steel rebar (0.953 cm diameter) and were constructed of three vertical rebar poles with two long rebar channels for the top and bottom (Smith et al. 2003). The bottom of the vertical bars were extended 15 cm below the horizontal bar to be stuck into the ground and were covered with a fiberglass window screening and a plastic mess to ensure durability and strength (Smith et al. 2003). The panels were also hinged in the middle to allow for maneuvering in the forest rather than one long panel. A total of 8 panels were used during the morning captures. On the morning of the brood capture before day break, the radio-collared parent(s) were located using the homing technique. Once a general area was determined, observers would triangulate the radio-collared
parent(s) with greater than 3 directions within 3-5 meters to determine the exact roost location. Small flashlights were used facing inward to provide observers the area where the parent(s) and chicks were roosted to allow for panels to be erected. After the panels were erected, vegetation was quietly pulled from around the base of the panels. The overhanging fiberglass screening was buried under the ground at the areas of vegetation that was removed. Panels were then buried to prevent chicks from escaping. Panel corners were also reinforced with braces to prevent chicks from escaping.

**Data Analysis**

For the nesting season demographic analysis many important terms are used to describe nesting information (Table 3.1). Hen count is the number of hens that are alive at the beginning of the nesting season. The nests per hen describes the number of females that attempt a nest (\( \geq 1 \) egg) divided by the number of females alive at the beginning of the breeding season. For this analysis, the breeding season begins in April 15th. An important reproductive parameter that is often overlooked or not calculated is chick survival after leaving the nest. Nest success describes the proportion of nests that hatched \( \geq 1 \) egg. The parameter of hatches per hen describes the number of successful hen hatches (\( \geq 1 \) egg) divided by the number of hens alive at the beginning of the breeding season.

Broods were captured at 8 days of age, if the brood survived to that age. Apparent chick survival was determined by calculating chick survival rates of each independent clutch and obtaining an overall chick survival from the means of the independent clutches during 2006 and 2007 for wild, parent-reared, and fall release bobwhites. We used an 8 day apparent chick survival for each brood and calculated average chick survival across all the broods. We assumed
that there was no difference among broods in rates of brood amalgamation (Faircloth et al. 2005).

**RESULTS**

We monitored 4 types of bobwhites on Pinion Point Plantation [wild, parent-reared, pen-reared, and fall release bobwhites, but pen-reared was excluded from all analysis due to very low survival and recaptures (n=3)]. During 2006, wild (n=35), parent-reared (n=7), and fall release (n=14) hens incubated 37, 2, and 2 nests, respectively (Table 3.2). Of these nests, bobwhites successfully hatched 26, 1, and 1 nests, respectively. Nests per hen (alive April 15th) were 1.06 (n=37) for wild, 0.29 (n=2) for parent-reared, and 0.14 (n=2) for fall release bobwhites. Apparent nest success was 0.83, 0.50, and 0.50 for wild, parent-reared, and fall release in 2006, respectively. Average clutch sizes were similar 12.5 (11.5-13.6, 96% CI), 13.0 (9.1-16.9, 96% CI), and 12.5 (9.6-15.4, 96% CI) for wild, parent-reared, and fall release bobwhites (Figure 3.3). Clutch sizes in the fall release bobwhites were greater than the wild bobwhites. One female fall release bobwhite attempted a nest with a clutch size of 27 eggs, hatched 21 eggs, but had no chicks at 8 days of age. All wild, parent-reared, and fall release bobwhite chicks were captured (100% capture) and resulted in an estimated chick survival of 24.0% (n=16), 71.0% (n=1), and, 0.0% (n=1), respectively (Table 3.3).

During 2007, wild (n=29), parent-reared (n=12), and fall release (n=21) hens incubated 31, 4, and 19 nests and successfully hatched 19, 3, and 8, respectively. Nests per hen (alive April 15th) were 1.07 (n=31) for wild, 0.33 (n=4) for parent-reared, and 0.90 (n=19) for fall release bobwhites. Average clutch sizes were also similar 14.4 (12.8-15.9, 96% CI), 14.3 (10.6-17.9, 96% CI), and 17.1 (15.3-19.0, 96% CI) for wild, parent-reared, and fall release bobwhites in
2007, respectively (Figure 3.3). Apparent chick survival for wild, parent-reared, and fall release bobwhites for the 2007 breeding season was 31.0% (n=13), 28.0% (n=6), and 13.0% (n=8), respectively (Table 3.3). Parent-reared males were responsible for 4 nests in 2007 but were not included in the analysis since hens were not linked to wild or parent-reared bobwhites. Males hatched all 4 nests and reared 2 successful broods to 8 days of age.

**DISCUSSION**

Our results demonstrated that there were great differences in reproductive parameters of pen-reared and parent-reared bobwhite chicks. Due to small sample sizes of parent-reared chicks, statistical significance of parameters of interest was difficult to obtain. However, the data suggests some important biological patterns. Many other studies on fall release bobwhites have shown potential for reproduction (Dollar 1969, DeVos and Speake 1995). However, nesting may not give us a complete view of recruitment by these individuals. Reduced chick survival is common after fall release bobwhites leave the nest, possibly due to the lack of brooding ability and incorrect anti-predator behaviors (Dowell 1992). Low survival and incorrect behaviors ultimately reduced recruitment into the population. Hill and Robertson (1988) found that wild pheasants (*Phasianus colchicus*) produced 7 times the chicks surviving to 12 weeks of age than were produced by released pheasants. Poor behavior characteristics included extensive “lost” calls by pen-reared chicks post-release, flying into undergrowth from release boxes, lack of avoidance of human observers, and improper hiding behaviors. Pen-reared chicks did not hide in vegetation as frequently as parent-reared chicks. During brood captures, fall release bobwhites who received no parental care displayed abnormal behavior such as flying up into pine trees and producing the “lost chick” call. Other abnormal behaviors were that birds
would circle brood panels less than 1 m from observers. Another incident involved a fall release bobwhite trying to attack or “flog” the conductors of the brood capture.

Parent-reared, fall release, and wild bobwhites had similar clutch sizes. Nesting attempts by parent-reared chicks were possibly lower because of smaller sample sizes. Parent-reared hens and wild bobwhites produced similar numbers of chicks to 8 days of age. Results of brooding ability in the parent-reared bobwhites were similar to the gray partridge (\textit{Perdix perdix}), where parent-reared chicks brooded greater numbers of chicks (Brittas et al. 1992, Dowell 1992). However, parent-reared hens did not attempt as many nests as both the fall release and wild bobwhites during 2007. The reason is probably due to the smaller sample size of this group. Parent-reared bobwhites did lay two nests that were never incubated. Radio-collared individuals were seen on the nest, adding to the clutch on a daily basis, but never initiated incubation of the nest. Male parent-reared bobwhites contributed as much to incubation activities as the female parent-reared chicks. Male wild bobwhite also contributed to incubation and brooding activities.

We would caution managers in using pen-reared bobwhites for the purpose of restoring populations at a local level. Our findings concur with other studies that fall release bobwhites should not be used to restock depleted local populations (Roseberry et al. 1987, DeVos and Mueller 1989, DeVos and Speake 1995). Fall release bobwhites should also be banded in areas where wild populations exist to keep from over-harvesting wild bobwhites. Fall release bobwhites had similar reproductive demographics as wild bobwhites in nest per hen but lower nest success. Their hatches per hen were lower than desired and only 13.0% of the chicks survived to 8 days of age. Parent-reared bobwhites nesting success and hatches per hen were similar to fall release bobwhites. Parent-reared bobwhites attempted fewer nests, but had similar chick production to 8 days of age as wild bobwhites. Managers should be careful when using
fall release bobwhites because actual recruitment is overestimated only using nesting success. The rearing process of pen-reared bobwhites likely has negative effects on reproductive output and survival. Behaviors learned during early days of life may limit these birds ability to survival and reproduce.

Our study suggested that chicks reared under a species specific parent increased the ability of these individuals to raise broods and may increase survival. Larger sample sizes are needed to have a better understanding of potential recruitment of parent-reared chicks. Other interests would be to have a better understanding of the movements of chicks post-release. The use of radio-collars was attempted on a small subsample of the chicks to track movements but had little success due to problems with the adhesive attachment. Future studies should focus in areas of low bobwhite populations to determine the impact of wild bobwhites on this restoration technique.

LITERATURE CITED


Dollar, W. M. 1969. Movements, survival, and behavior patterns of pen-raised bobwhite quail (Colinus virginianus) on an established management area. Thesis, Auburn University, Auburn, AL.


Table 3.1. The following table provides definitions of the variables of interest for the nesting season demographics.

<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hen Count</td>
<td>Describes the number of hens that are alive at the beginning of the nesting season. For this analysis, the breeding season begins on 15 April</td>
</tr>
<tr>
<td>Nests/hen</td>
<td>Describes the number of females that attempt a nest ($\geq 1$ egg) divided by the number of females alive at the beginning of the breeding season</td>
</tr>
<tr>
<td>Nest Success</td>
<td>Describes the proportion of nests that hatched $\geq 1$ egg</td>
</tr>
<tr>
<td>Hatches/hen</td>
<td>Describes the number of successful hen hatches ($\geq 1$ egg) divided by the number of hens alive at the beginning of the breeding season</td>
</tr>
</tbody>
</table>
Table 3.2. Breeding season calculations for wild, parent-reared, and fall release bobwhites during 2006 and 2007 at Pinion Point Plantation. The hen count is the number of hens alive on April 15th of the breeding season.

<table>
<thead>
<tr>
<th>Year</th>
<th>Type</th>
<th>Hen Count</th>
<th>Nests</th>
<th>Nest/hen</th>
<th>Nest Success</th>
<th>Hatches/hen</th>
</tr>
</thead>
<tbody>
<tr>
<td>2006</td>
<td>Wild</td>
<td>35</td>
<td>37</td>
<td>1.06</td>
<td>0.83</td>
<td>0.87</td>
</tr>
<tr>
<td></td>
<td>Parent-reared</td>
<td>7</td>
<td>2</td>
<td>0.29</td>
<td>0.50</td>
<td>0.14</td>
</tr>
<tr>
<td></td>
<td>Fall Release</td>
<td>14</td>
<td>2</td>
<td>0.14</td>
<td>0.50</td>
<td>0.07</td>
</tr>
<tr>
<td>2007</td>
<td>Wild</td>
<td>29</td>
<td>31</td>
<td>1.07</td>
<td>0.61</td>
<td>0.66</td>
</tr>
<tr>
<td></td>
<td>Parent-reared</td>
<td>12</td>
<td>4</td>
<td>0.33</td>
<td>0.50</td>
<td>0.17</td>
</tr>
<tr>
<td></td>
<td>Fall Release</td>
<td>21</td>
<td>19</td>
<td>0.91</td>
<td>0.42</td>
<td>0.38</td>
</tr>
</tbody>
</table>
Table 3.3. Bobwhite chick survival estimates were determined by calculating each independent clutch survival rate and calculating the mean of those survival rates to get an overall chick survival rate to 8 days of age for wild, parent-reared, and fall release bobwhites for the summers during 2006 and 2007 at Pinion Point Plantation.

<table>
<thead>
<tr>
<th>Year</th>
<th>Type</th>
<th># Nests</th>
<th># of Hatched Nests</th>
<th>Chick Survival</th>
</tr>
</thead>
<tbody>
<tr>
<td>2006</td>
<td>Wild</td>
<td>29</td>
<td>16</td>
<td>24.0%</td>
</tr>
<tr>
<td></td>
<td>Parent-reared</td>
<td>2</td>
<td>1</td>
<td>71.0%</td>
</tr>
<tr>
<td></td>
<td>Fall Release</td>
<td>2</td>
<td>1</td>
<td>0.0%</td>
</tr>
<tr>
<td>2007</td>
<td>Wild</td>
<td>21</td>
<td>13</td>
<td>31.0%</td>
</tr>
<tr>
<td></td>
<td>Parent-reared</td>
<td>8</td>
<td>6</td>
<td>28.0%</td>
</tr>
<tr>
<td></td>
<td>Fall Release</td>
<td>19</td>
<td>8</td>
<td>13.0%</td>
</tr>
</tbody>
</table>
Figure 3.1. Study site location at Pinion Point Plantation in Brooks County, Georgia.
Figure 3.2. Design of parent-reared pens for the experiment was based on the trapezoidal shape from previous studies by Stoddard (1931).
Figure 3.3. Average clutch sizes of wild (n=36, 28), parent-reared (n=2, 4), and fall release bobwhites (2, 14) with 95% confidence intervals for 2006 and 2007, respectively.
CHAPTER 4
CONCLUSIONS AND FUTURE RESEARCH

Northern Bobwhite Quail (Colinus virginianus) (hereafter, bobwhite) populations have been studied extensively to determine possible reasons for their decline. These declines have stimulated the use of pen-reared bobwhites throughout the entire southeastern United States. Pen-reared bobwhites have been studied extensively to determine possible reasons why these birds have lower survival and lower reproductive output than wild bobwhites. Studies have been conducted with small sample sizes and have not examined effects of parent-rearing and rearing in semi-natural environments early in life. We focused on the effects that parent-rearing and rearing in the semi-natural environment on chick returns, survival, and reproductive output. Treatments consisted of parent-reared, pen-reared, fall release, and wild bobwhites to compare the return rates, survival, and nesting season demographics.

Parent-reared bobwhites exhibited greater returns than their pen-reared counterpart on Pinion Point Plantation in South Georgia. Parent-reared birds generally returned 10% in October trapping sessions and 2% to the following March trapping sessions. Pen-reared chicks had limited returns (n=6) for the length of the study and averaged less than a 1% return rate. We also examined survival of parent-reared chicks post-release to determine recruitment into the following breeding season. Parent-reared chick over-winter survival was 30% during 2006. Over-winter survival for wild bobwhites in the area of south Georgia range from 30 to 60% (Terhune et al. 2007). Movements from release to trapping sessions were similar by both of
these groups, which suggests than no movements were seen off study areas. This assumption was supported by physical barriers on the property and harvest returns from hunting parties.

Reproductive demographics were examined for parent-reared, fall release, and wild bobwhites on Pinion Point Plantation in South Georgia. Small sample sizes during 2006 resulted in little information about reproductive demographics of all groups except wild bobwhites. During 2007, fall release bobwhites nested at similar rates as wild bobwhites on Pinion Point Plantation. Nest per hen rates for these two groups were around 1 nest per hen. Fall release bobwhite chick survival was less than wild or parent-reared bobwhites. Many studies have suggested the possibility for fall release bobwhites to reproduce if they survival to the breeding season (Dollar 1969, DeVos and Speake 1995). However, lower chick survival was observed in our study possibly due to poor brooding and incorrect anti-predator behaviors (Dowell 1992). Observers noticed many correct behaviors by parent-reared bobwhites post-release, while fall release bobwhites generally displayed many incorrect behaviors such as flying into trees, mobbing observers, and increased mortality during brooding periods.

During 2007, wild and parent-reared bobwhites had similar chick survival of 31% and 28%, respectively. Parent-reared chicks did not readily nest as frequent as wild or fall release bobwhites. Possible explanations were allocated to small sample sizes of these individuals. However, we believe some biological significance was achieved from the experiment. Parent-reared chicks displayed correct behaviors, increased reproductive output, and increased survival over previous pen-reared studies. Parent-rearing and rearing in the semi-natural environment allowed parent-reared bobwhites to supersede the pen-reared bobwhites and increased recruitment into future populations. Progress can now be expanded to other projects to determine the full extent of the process for restoration purposes. From the study, we concluded
using pen-reared bobwhites released early in their life was not beneficial for significant survival or recruitment into the wild population.

We used the survival and reproductive parameters along with their respective variances from our study to project the parent-reared bobwhite population using program QUAILSIM (Weinstein et al. 2008). We ran the discrete model setting parameters for second and third nesting attempts to 0 due to no observations of more than one nesting attempt. Chick survival estimates by parent-reared bobwhites was decreased by 10% to account for the entire breeding season rather than the early period we measured. Simulations were run for 50 years with 2,000 iterations per year with the initial population of 441 bobwhites. Display output was selected for spring periods. From this analysis, parent-reared populations persisted for 18 years (Figure 4.1). However, the last 3 years consisted of only a few individuals. From our study, we have shown positive results for parent-reared bobwhites over pen-reared bobwhites and future research is needed to fully understand this relationship.

**FUTURE RESEARCH NEEDS**

Many possibilities exist for future studies to enhance our knowledge on bobwhite biology and behaviors surrounding the effects of parent-rearing and rearing in the natural environment with bobwhites. Parent-reared bobwhites released on our study area mixed with wild bobwhites of moderate densities. Therefore, we could not determine the overall effect that wild bobwhites had on parent-reared bobwhites on the property. Future studies should examine this technique with low or no populations of wild bobwhites to determine the extent wild bobwhites enhanced survival and reproductive output of the released bobwhites. Variations of parental rearing
techniques may be attempted to determine influence of adult experience on success. For example, wild-trapped adults might be tested to assess behavior differences.

Our study was also confounded by the influence of two treatments: parent-rearing and rearing in the natural environment. Future studies should examine these two distinct treatments to determine if one is more important for correct behaviors of released birds. Rearing pens might be modified to determine behavioral differences and determine if rearing in the semi-natural environment is important to the development of future behaviors. The comparison between the parent-rearing and rearing in the semi-natural environment could be teased apart to determine if these have additive impacts on the behavior or independent factors.

LITERATURE CITED


Dollar, W. M. 1969. Movements, survival, and behavior patterns of pen-raised bobwhite quail (Colinus virginianus) on an established management area. Thesis, Auburn University, Auburn, AL.


Weinstein, M., L. W. Burger, and M. Fies. 2008. QUAILSIM Version 1.0. Mississippi State University, Mississippi State, MS.
Figure 4.1. Parent-reared bobwhite quail abundance projections from program QUAILSIM based on recruitment and survival estimates from Pinion Point Plantation during 2006 and 2007.