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Comparison of Survival, Productivity, Movements, and Habitat Use of Pre-Season Released Quail on Wild Northern Bobwhites on Groton Plantation, South Carolina

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To understand the effects of a pre-season release operation (liberating pen-raised quail for hunter harvest) on native quail (*Colinus virginianus*) populations, we developed studies to assess population demographics and movements of three treatment groups (wild, pen, and wild/pen quail) on Groton Plantation, Allendale County, South Carolina. Two isolated study sites were selected: a site with only wild quail (control) and a site with both wild quail and pen-raised quail released each September (treatment). We radio-tagged wild ($n = 306$) and pen-raised ($n = 330$) quail during 1996 and 1997, for monitoring various demographic parameters, including body weight, survival rate, home range, habitat use, linear dispersal, and hunting susceptibility. Based on data from this study, the release of pen-raised quail affected the behavioral characteristics of wild quail and possibly physical characteristics such as body weight. Individual body weight measurements indicated that a higher percentage of wild/pen quail weighing more than wild quail during both years (March 1996 and 1997). While these data are not direct measurements of introgression, reproductive success of pen-raised quail was observed during two consecutive breeding seasons (44% and 22%). Behavioral characteristics such as home range size, habitat-use, and linear dispersal were different between wild/pen and wild control quail during specific periods (i.e., season and year) potentially causing lower survival rates (0.077 ± 0.074) during the 1997 overwinter season and increased hunter susceptibility. While the pre-season release of pen-raised quail can produce economically efficient hunting, negative impacts on native quail population may occur.

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Key words: *Colinus virginianus*, northern bobwhite, pen-raised quail, pre-season release, South Carolina

Introduction

The pre-season release of pen-raised northern bobwhite quail (hereafter: quail) has become a common management practice for landowners interested in augmenting quail populations for hunting. Typically, in a pre-season release operation, pen-raised quail are released two months prior to the start of hunting season, which may provide them to acclimation to their new environment and develop suitable flight characteristics more similar to their wild counterparts. DeVos and Speake (1995) suggested that pen-raised quail could acquire wild characteristics such as sustained holding times be-

fore flushing, increased flight intervals, social continuity as a flushing covey, and similar summer survival rates.

Many concerns regarding the ecological impacts of releasing pen-raised quail on wild quail have been postulated. Two problems proposed are a reduction in survival due to increased mortality from predators and reduced fitness of native quail (Landers et al. 1991). DeVos and Speake (1995) have documented that pen-raised quail interact within wild coveys, and presumably are able to nest successfully; however, the latter lacks empirical support. Most research involving pen-raised quail has focused solely on their fate and dispersal among varying habitat

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conditions, and not on their interactions with native quail populations or possible reproductive contribution.

Our research objective was to determine the effects of pre-season released quail on the demographics, habitat use, and dispersal of a native quail population in the coastal region of South Carolina. To accurately assess these impacts we used a site managed strictly for wild quail as our experimental control. We quantified body weight, survival rates, cause-specific mortality, hunter harvest, linear dispersal, home range, and reproductive success.

Study Area

Research was conducted on Groton Plantation located in the lower coastal plain of Allendale County, South Carolina adjacent to the Savannah River. Two study sites were selected, a pre-season release area (PR) and a control site (WC) managed strictly for wild quail. The linear distance between the two sites was approximately 2.4 km to minimize quail movements between study sites. Both sites were similarly managed to promote quality quail habitat. The PR site (789 ha) was comprised of upland forests (38%), field systems (34%), transitional buffers (22%) and lowland areas (6%). The WC site (406 ha) was comprised of field systems (43%), upland forests (31%), transitional buffers (21%) and lowland area (5%).

Field systems were divided into two major components: disked fields and fallow hedgerows. Fallow hedgerows comprised roughly two-thirds of the field system, whereas disked fields accounted for the remaining one-third. Disked fields were maintained by annual fall and mid-winter harrowing. Fallow hedgerows were border areas within the field system, established for protective refuge (escape cover) and traveling corridors for quail. Upland forest habitat consisted mostly of mixed pine/hardwoods (*Pinus* spp. and *Quercus* spp.) with an average stand density of 6 - 13 m² /hectares. Approximately 80% of each site was annually burned during winter. Lowland sites were typically defined as bottomland hardwoods, which regularly flooded or had high soil saturation characteristics and scarce

ground story vegetation. Transitional buffers were defined as a 20 m interval zone between field systems and upland forests (10 m into each habitat type from the juxtaposition).

Methods

Trapping

Quail were captured using night netting and standard walk-in funnel traps (Stoddard 1931) baited with sorghum. Each trap site was pre-baited for approximately one month and pre-season release sites were supplementally fed throughout the hunting season for both study years. The wild control site was supplementally fed only during the second study year. Quail were aged (Rosene 1969), sexed, weighed, banded, and fitted with a 6 g necklace transmitter (American Wildlife Enterprises, Monticello, FL 32344) if their weight exceeded 130 g. Transmitters had mortality indicators that were activated after a motionless period of 12 hours. Trapping was conducted until at least 30 radio-tagged quail had survived greater than 1 week on each treatment site.

Quail were classified into three treatment groups: wild, wild/pen, and pen-raised quail. Native quail captured from the WC site were referred to as "wild", whereas unbanded native quail captured from the PR site were referred to as "wild/pen." Pen-raised quail, referred to as "pen" were leg banded prior to release for identification and were either trapped or released on the PR study site. Research study was conducted from March 1996 to March 1998 and years were divided into two distinct seasons, breeding season (Mar-Sep) and overwinter season (Sep-Mar) within each year.

Telemetry

Radio-tagged quail were monitored using homing techniques (White and Garrott 1990) with a 2-element "H" antenna and receiver. All birds were tracked ≥ 3 days per week and locations were recorded on maps generated with AtlasGIS. Each location was assigned UTM coordinates and a habitat-use classification such as field systems, uplands,

Table 1: Trapping weight results analyzed for treatment groups (pen, wild/pen, and wild) by season and year on Groton Plantation, Allendale County, SC.

Trapping Period	Trt Group	<i>n</i>	Weight (g)	SE	Quail >183.3g
Mar-96	Pen ^a	64	206.3	1.875	64
Mar-97	Pen ^c	74	201.2	1.744	66
Mar-96	Wild/Pen	34	177.9	2.573	13
Mar-97	Wild/Pen	49	171.9	2.122	11
Mar-96	Wild	54	161.9	2.042	2
Mar-97	Wild	43	172.3	2.288	2
Sep-96	Pen ^b	97	175.5	1.523	25
Sep-97	Pen ^b	104	190.4	1.471	56
Sep-96	Wild/Pen	41	153.6	2.343	1
Sep-97	Wild/Pen	29	186.7	2.786	15
Sep-96	Wild	43	144	2.288	0
Sep-97	Wild	40	159.8	2.372	2

^aTrapped pen-raised quail that were released on or before Sept 22, 1995, ^b 10 to 12-week-old, pen-raised quail which have not yet been released into the wild, ^cTrapped pen-raised quail that were released on or before Sept 24, 1996.

transitional buffers, and lowland areas. Female quail were tracked once per day throughout the breeding season. Upon successful hatching, two daily locations were recorded until chicks reached flight stage (approximately 2 weeks after hatch). Nesting data such as clutch size, percent catch, nest predation and nest abandonment were also collected during this period. We left-censored quail that moved off the study site, had radio-transmitter failure, or died within the first week of radio-transmitter attachment due to acclimation stress and possible predator induced emigration at release sites (Pollock et al. 1989b, Curtis et al. 1989). Cause specific mortality was categorized into four predator classes (i.e. avian, mammalian, hunter, and reptilian) by studying the post-mortem remains, condition of the transmitter (teeth or beak marks), and other evidence at the kill site (tracks, avian whitewash, feathers, bones, etc.; Curtis et al. 1989).

Hunter Harvest

Substantiated efforts to minimize harvest effects were incorporated in management plans on both study sites by extending time between hunts (designated hunting sites were only hunted once every 14 days), allowing no more than 3 birds to be harvested on any given covey, and equalizing hunting pressure throughout the hunting season to avoid over-harvest during late-winter.

Statistical Analysis

$$\bar{x} \pm t * \left(\frac{\sigma}{\sqrt{1 + \frac{1}{n}}} \right)$$

Body Weights - Wild quail weights on pre-season release sites (wild/pen) were examined for possible introgression effects by calculating the upper 95% confidence interval for individual wild quail weights (control quail from WC) and testing the difference in probability of capturing a wild or wild/pen quail weighing greater than the 95% CI value by chi-square analysis (PROC FREQ; SAS Institute, Inc. 1989). Only weight data from the March trapping periods were used in these analyses since

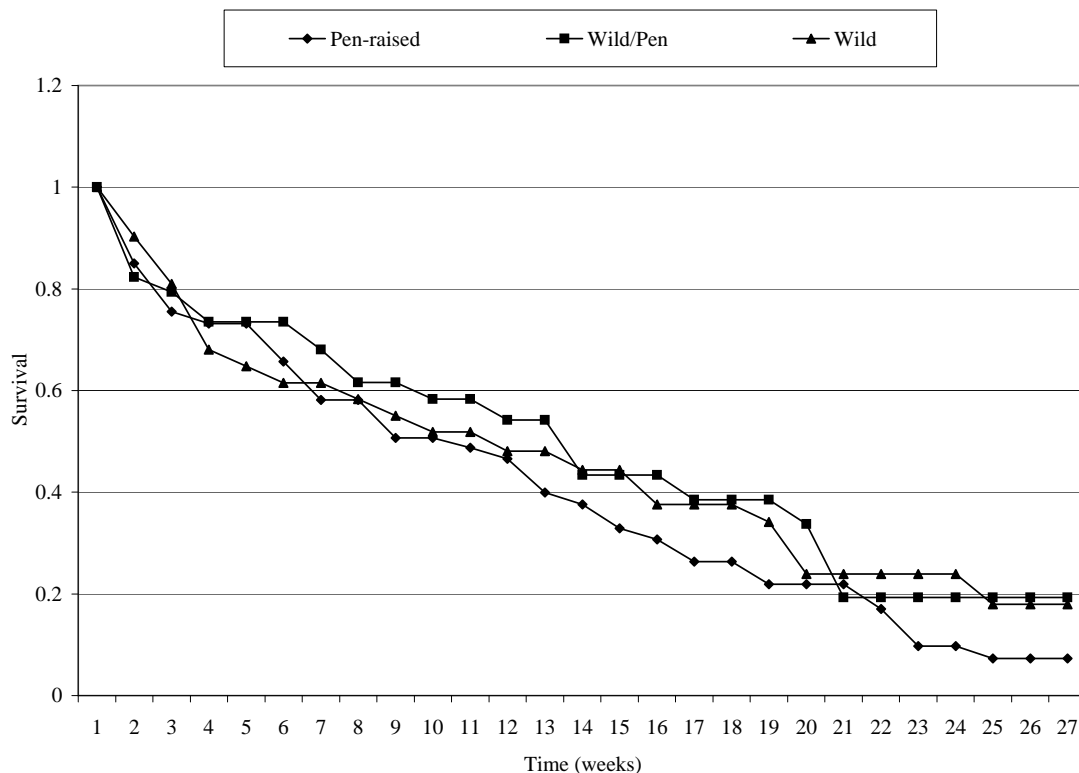


Figure 1: Estimated survival rates of treatment groups (pen, wild/pen, and wild) using a Kaplan-Meier Staggered Entry Design for breeding season year one (18-March to 22-September 1996).

juvenile quail may have negatively influenced the results.

Survival Rates - The Kaplan-Meier staggered entry design (Kaplan and Meier 1958) modified by Pollock et al. (1989a) was used to determine weekly survival rate of each treatment group (pen, wild/pen, and wild). Differences in weekly survival rates between treatment groups were tested using a modified normality test (Pollock et al. 1989a). The log rank test modified by Pollock et al. (1989b) was used to test for differences in survival rates among seasons (overwinter or breeding) and between treatment groups.

Cause-Specific Mortality - Chi-square analysis (PROC FREQ; SAS Institute, Inc. 1989) was used to determine differences in cause-specific mortality between treatment groups (pen, wild/pen, and wild) by year and between years for each treatment group. Reptilian predation was excluded from the analyses

due to low frequency of occurrence.

Home Range - Data were analyzed for each treatment group (pen, wild/pen, and wild) by season (overwinter and breeding) and year (1996 and 1997). A minimum number of thirty locations per quail are suggested for home range analysis (Brewer and Fagerstone 1998); however, due to the temporal tracking period (>38 days) and sample size requirements, individual quail with ≥ 20 locations were used in the analysis. Home range sizes were estimated using 95% adaptive kernel isopleths (Worton 1989), which were generated using ArcView 3.2 (Home Range Extension Program (HRE); ESRI 1989, Rodgers and Carr 1998). The smoothing parameter was estimated using least squared cross validation (LSCV; Worton 1989). The selection of this home range estimator and smoothing parameter was based on the non-normality of the data sets (Seaman and Powell 1996). Due to non-normally dis-

tributed home range data for all treatment groups (PROC UNIVARIATE; SAS Institute, Inc. 1989), a logarithmic scale was applied to all home range estimates. Log mean home ranges were compared among treatment groups by year using a one-way analysis of variance (ANOVA, PROC GLM; SAS Institute, Inc. 1989) with LSD as the mean separator.

Habitat-Use - Habitat use data were analyzed using a two-step procedure described by Neu et al. (1974). Chi-square analysis was used to test the null hypothesis that habitat-use was proportional for all habitat types and the z-Bonferroni test was used to determine selection or avoidance of a particular habitat type by calculating a 95% confidence interval for expected use and comparing the values to the observed availability (total hectares of habitat type).

Linear Dispersal - Linear dispersal distance was defined as the farthest linear distance between a quail's release/trap site and observed location. Linear dispersal distances were analyzed for treatment groups by season and year using a one-way ANOVA (PROC GLM) and LSD as the mean separator.

Hunting Harvest On Pre-Season Release Sites - Chi-square analysis was used to test for differences in ratios of wild to pen-raised quail harvested per year (1996-97, 1997-98, and 1998-99) on all pre-season release sites.

Nesting/Reproductive Success - Statistical analysis was not conducted on this data set due to low sample sizes ($n < 13$), but results are presented in Table 3. An alpha level of 0.05 was established as the significant threshold for all statistical analyses conducted in this study.

Results

Body Weights

We weighed 152 quail in March 1996 and 166 quail in March 1997 (Table 1). The average weight was $206.3 \pm 11.3\text{g}$ for pen-raised ($n = 64$), $177.9 \pm 16.8\text{g}$ for wild/pen ($n = 34$), and $161.9 \pm 10.6\text{g}$ for wild quail ($n = 54$) in March 1996, and $201.1 \pm 14.6\text{g}$ for pen-raised ($n = 74$), $171.8 \pm 20.8\text{g}$ for wild/pen ($n = 49$), and $172.3 \pm 7.6\text{g}$ for wild quail ($n = 43$) in March 1997 (Table 1). To assess possible introgress-

sion effects, upper confidence intervals (95% C.I.) for wild quail were calculated as 183.3g for March 1996 and 187.5g for March 1997. Wild/pen quail had a greater probability of weighting more than the upper 95% CI for wild quail during both the 1996 trapping period (38.2%; $P = 0.0004$) and 1997 (22.5%; $P = 0.0145$). During these trapping periods, only 3.7% (1996) and 4.7% (1997) of wild quail weighted more than the upper 95% CI (Table 1).

Survival Rates

Groups By Season - For the 1996 breeding season, estimated survival of wild/pen quail (0.193 ± 0.023 , mean \pm SE) was greater than wild (0.179 ± 0.081) and pen-raised quail (0.73 ± 0.023), but not statistically different ($P = 0.3576$ and $P = 0.2112$; Figure 1). Similar to the 1996 breeding season, estimated survival of wild/pen quail (0.105 ± 0.019) was greater than wild (0.069 ± 0.022) and pen-raised quail (0.030 ± 0.029), but not statistically different ($P = 0.5092$ and $P = 0.1556$) during the 1997 breeding season (Figure 2). Differences in estimated survival by weekly comparisons were only observed during the latter breeding season between pen-raised quail and both wild/pen (weeks 5 thru 25 except week 9; $P < 0.002$ to $P = 0.0424$) and wild quail (weeks 4 thru 23; $P < 0.002$ to $P = 0.0208$). For the 1996 overwinter season, estimated survival of wild quail (0.594 ± 0.027) was greater than wild/pen (0.417 ± 0.053) and pen-raised quail (0.115 ± 0.108), but only the comparison between wild and pen-raised quail was statistically different ($P < 0.002$; Figures 3). Differences in estimated survival by weekly comparisons for the 1996 overwinter season were only observed between pen-raised quail and both wild/pen (weeks 9 thru 20 and week 24; $P < 0.002$ to $P = 0.0366$) and wild quail (weeks 9, 11 and 14 thru 25; $P < 0.002$ to $P = 0.0434$). During the 1997 overwinter season, estimated survival of wild quail (0.448 ± 0.025) was statistically greater than pen-raised (0.152 ± 0.070 ; $P = 0.0292$) and wild/pen quail (0.077 ± 0.074 ; $P < 0.002$). Differences in estimated survival by weekly comparisons for the 1997 overwinter season were only observed

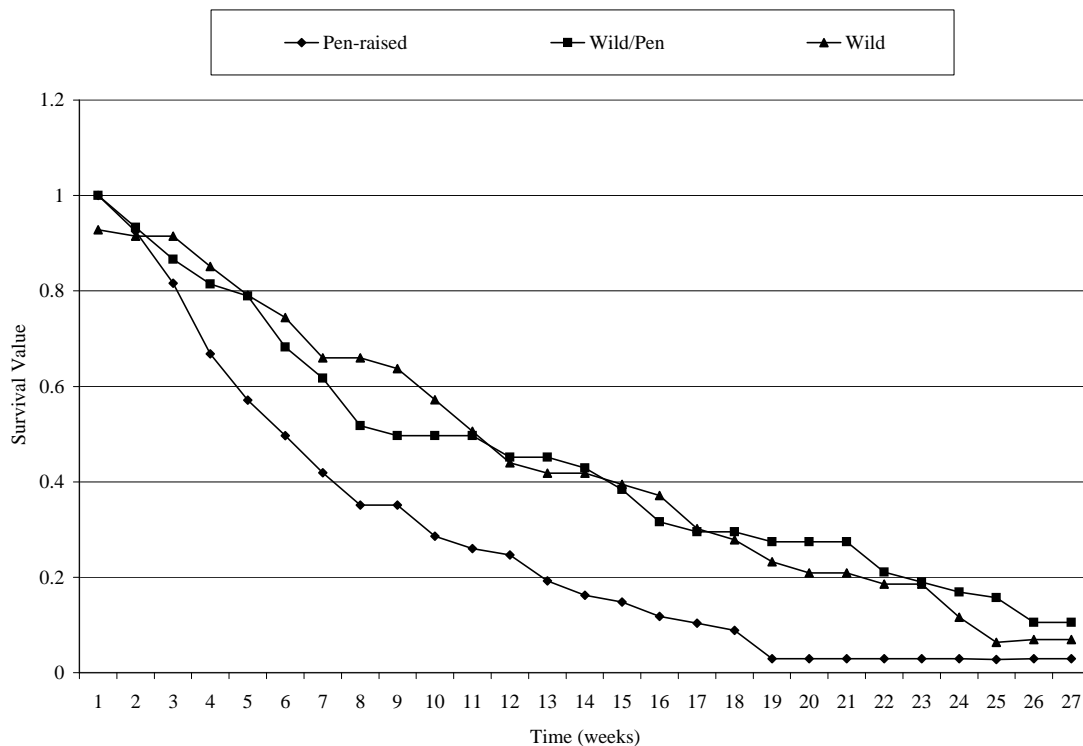


Figure 2: Estimated survival rates of treatment groups (pen, wild/pen, and wild) using a Kaplan-Meier Staggered Entry Design for breeding season year two (10-March to 14-September 1997).

between wild quail and both wild/pen (weeks 9 thru 15, 16, 20, and weeks 22 thru 25; $P < 0.002$ to $P = 0.0324$) and pen-raised quail (all weeks; $P < 0.002$ to $P = 0.0292$). The estimated survival of pen-raised birds from time of release to the start of the hunting season was 0.608 ± 0.008 for 1996 and 0.589 ± 0.006 for 1997 (Figures 3 and 4).

Between Years - For the breeding season, only the data sets of pen-raised quail showed significant differences between years in survival curves ($\chi^2 = 7.718$, $df = 1$, $P < 0.05$). For the overwinter season, only the data sets of wild/pen quail showed significant differences between years in survival curves ($\chi^2 = 3.995$, $df = 1$, $P < 0.05$).

Cause-Specific Mortality

We identified cause-specific mortalities of 455 radio-tagged quail by predator class (avian, mammalian, reptilian, and harvest). Avian predators accounted for 51.7% of all mortalities (54% to

wild/pen, 51% to wild and 51% to pen-raised quail), followed by mammalian predators (26.3%), hunter (20.3%) and reptiles (1.7%). No statistical differences were observed among treatment groups by predator class; however, mammalian predation increased during the second study year for the all treatment groups (pen 19 to 36%, wild/pen 14 to 26%, and wild 18 to 34%).

Home Range

Pen-raised quail ($\bar{x} = 2.99 \pm 0.124$, $\bar{x} = 2.95 \pm 0.155$, mean \pm SE) had smaller log mean home ranges than wild quail ($\bar{x} = 3.52 \pm 0.174$, $\bar{x} = 3.44 \pm 0.141$) during the 1996 and 1997 breeding seasons ($P = 0.0124$ and $P = 0.0199$). Additionally, pen-raised quail ($\bar{x} = 1.75 \pm 0.093$, $\bar{x} = 1.73 \pm 0.088$) had smaller log mean home ranges than wild quail ($\bar{x} = 2.81 \pm 0.141$, $\bar{x} = 2.32 \pm 0.134$) during the 1996 and 1997 overwinter seasons ($P < 0.0001$ and $P = 0.0003$). Pen-raised quail had a smaller log mean home range

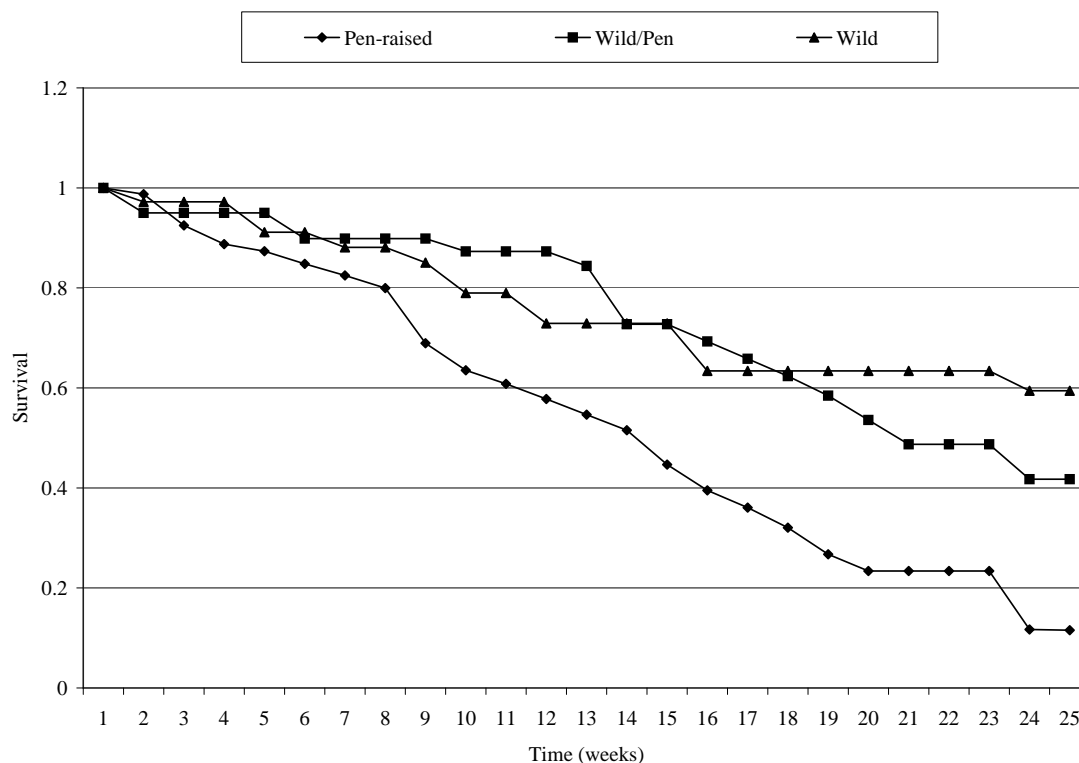


Figure 3: Estimated survival rates of treatment groups (pen, wild/pen, and wild) using a Kaplan-Meier Staggered Entry Design for overwinter season year one (16-September 1996 to 9-March 1997).

than wild/pen quail ($\bar{x} = 2.41 \pm 0.132$) for only the 1996 overwinter season ($P < 0.001$). After logarithmic adjustments, wild quail had significantly larger home range estimates than wild/pen quail for breeding ($\bar{x} = 3.52 \pm 0.174$ vs $\bar{x} = 2.93 \pm 0.146$, $P = 0.0099$) and overwinter seasons ($\bar{x} = 2.82 \pm 0.141$ vs $\bar{x} = 2.40 \pm 0.132$, $P = 0.0346$) in 1996, but were similar for both seasons in 1997 ($P = 0.2457$ and $P = 0.1733$). Logarithmic mean home range estimates were, however, larger for wild than wild/pen quail during the breeding and overwinter seasons ($\bar{x} = 3.44 \pm 0.141$ vs $\bar{x} = 3.20 \pm 0.146$ and $\bar{x} = 2.32 \pm 0.134$ vs $\bar{x} = 2.01 \pm 0.184$) during 1997. Estimated mean home ranges (hectares) of treatment groups by season are presented in Figure 5.

Habitat-Use

Wild quail selected for forested habitat types, used buffers in proportion to the total hectares avail-

able, and avoided for both field systems and lowland habitat types (Table 2). Wild/pen and pen-raised quail did not differ in habitat selection; both groups avoided forested and lowland habitat types while selecting for field types and used buffers in proportion to the total hectares available.

Linear Dispersal

Wild quail had the largest linear dispersal distances compared to wild/pen and pen-raised quail among all seasons and years (Figure 6). For the 1996 breeding season, linear dispersal measurements were greater for wild quail ($824.2 \text{ m} \pm 75.7$, mean \pm SE) compared to wild/pen ($635.9 \text{ m} \pm 63.5$, $P = 0.0469$) and pen-raised quail ($596.1 \text{ m} \pm 55.7$, $P = 0.0159$); however, no differences occurred during the 1997 breeding season ($P = 0.0773$ and $P = 0.4723$). For the 1996 overwinter season, linear dispersal measurements were greater for wild quail

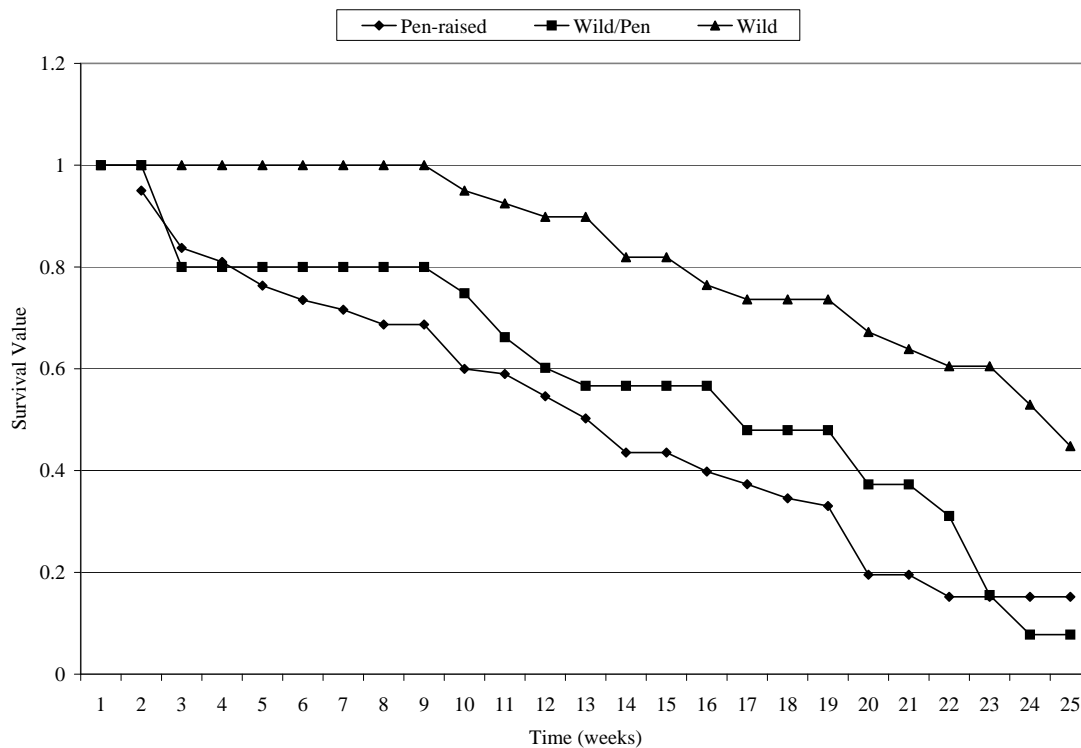


Figure 4: Estimated survival rates of treatment groups (pen, wild/pen, and wild) using a Kaplan-Meier Staggered Entry Design for overwinter season year two (15-September 1997 to March 1998).

(786.5 m \pm 90.2) compared to wild/pen (519.9 m \pm 85.2, $P = 0.0379$) and pen-raised quail (416.4 m \pm 53.5, $P = 0.0008$); however, no differences occurred during the 1997 overwinter season ($P = 0.4688$ and $P = 0.5227$).

Nesting/Reproductive Success

The ratio of nests located to successful nests decreased during the second study year (1997) for all treatment groups (Table 3). Number of nests predated increased during the second breeding season for pen-raised (33 to 55%), wild/pen (16.7 to 31.3%), and wild quail (30.0 to 41.7%) as well as nesting bird predation (Table 3).

Hunting Harvest On Pre-Season Release Sites

The ratio of wild to pen-raised quail harvested per year was collected from PR and nine other pre-season release sites during 1996-97 ($n = 133$), 1997-98 ($n = 92$) and 1998-99 ($n = 121$; Table 4). This ratio significantly decreased during consecutive hunt-

ing seasons including 1996-97 (0.191) and 1997-98 (0.109, $P < 0.0001$) and 1997-98 and 1998-99 (0.059, $P = 0.0035$).

Discussion

Body Weights

Individual body weights of treatment groups were analyzed to test the hypothesis that wild quail on a pre-season release site (PR) have weights greater than native wild quail located on a wild control site (WC). Results from the March trapping periods seemed to support that introgression effects (genetic mixing) might have occurred on PR, but conclusive data is still warranted to assess genetic changes in wild quail populations on pre-season release sites.

Survival Rates

DeVos and Speake (1995) and Sisson et al. (2000a) reported higher autumn survival rates for wild quail

Effects of Pre-season Release Quail on Wild Bobwhites

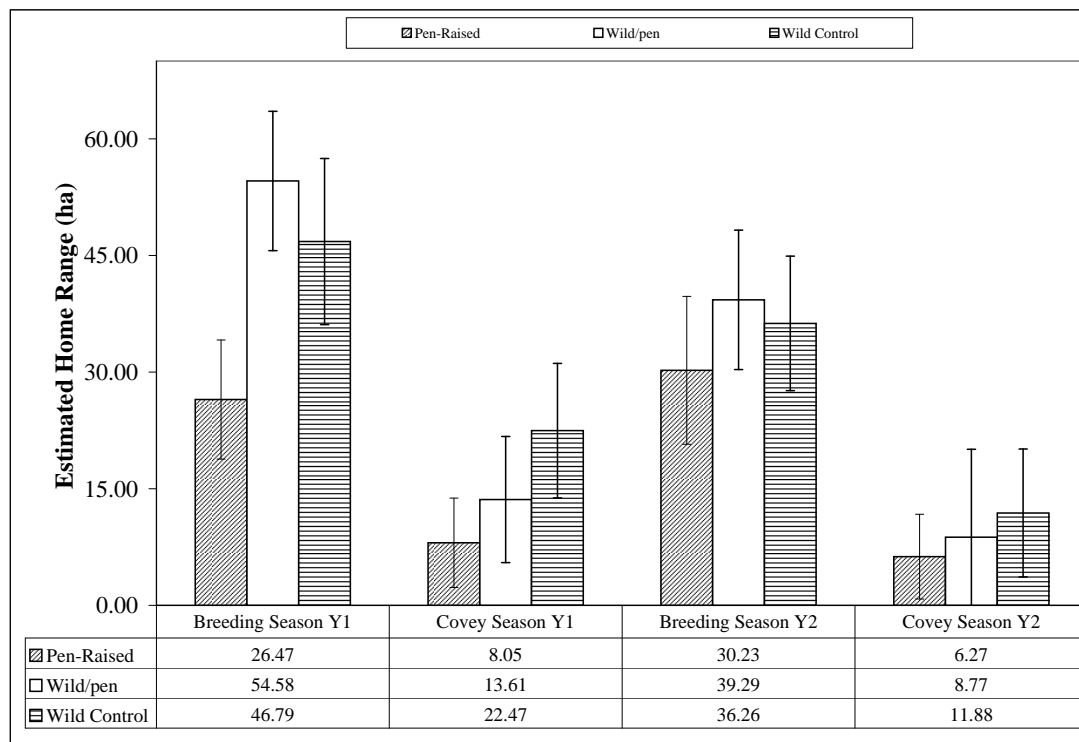


Figure 5: Home range (hectares) estimated using 95% adaptive kernel isopleths for treatment groups on Groton Plantation, Allendale, SC during two seasonal groups (overwinter and breeding season) for both study years. Error bars represent the standard error of the treatment mean.

on a control site compared to wild quail on a pre-season release site. Our results were similar to these studies, in that wild quail had higher survival rates (0.521) during overwinter seasons (pooled) compared to wild/pen (0.247) and pen-raised quail (0.133). Higher wild/pen survival rates for the 1996 versus 1997 overwinter season (0.417 and 0.077) may have been due to a time-dependent relationship between the release of pen-raised quail and various factors that may include predation dynamics (e.g. emigration, changes in prey selection, capture efficiency, and hunter susceptibility) and covey structure and function. Mammalian predation was not significantly greater between the 1996 and 1997 study years, but might have attributed to these findings as well as influences (Type II errors) caused by low sample sizes.

Cause-Specific Mortality

Avian species have been reported to cause the majority of predation against both liberated and native quail in the southeastern U.S. (Sisson et al. 2000a, DeVos and Speake 1995, Curtis et al. 1989). Avian species accounted for 63% of all identified mortalities within our study compared to 69% as reported by Sisson et al. (2000b), 86% by DeVos and Speake (1995) and 60% by Curtis et al. (1989). Mammalian predators accounted for the second most identified mortalities (33%), which is similar to values reported by Burger et al. (1995) and DeVos and Speake (1995). Statistical differences in cause-specific mortalities among quail groups did not occur in our study or in the studies of DeVos and Speake (1995) and Curtis et al. (1989).

Table 2: Habitat-use analysis using the Neu et al. (1974) procedure for quail treatment groups on Groton Plantation, Allendale County, South Carolina (18 March 1996 to 8 March 1998).

Treatment Group	Habitat Type	Total Loc.	Expected Use (P)	Observed Use (Pi)	Bonferroni ^a Confidence Int.	Result
Pen	Field systems	4294	0.339	0.532	0.518 = $P = 0.545$	Preference
Pen	Buffers	1812	0.224	0.224	0.213 = $P = 0.236$	Proportion
Pen	Forest	1973	0.378	0.244	0.232 = $P = 0.256$	Avoidance
Pen	Lowland	0	0.059	0	0 = $P = 0$	Avoidance
Wild/Pen	Field systems	2179	0.339	0.486	0.467 = $P = 0.504$	Preference
Wild/Pen	Buffers	1016	0.224	0.226	0.211 = $P = 0.242$	Proportion
Wild/Pen	Forest	1293	0.378	0.288	0.271 = $P = 0.305$	Avoidance
Wild/Pen	Lowland	0	0.059	0	0 = $P = 0$	Avoidance
Wild	Field systems	1811	0.431	0.308	0.293 = $P = 0.324$	Avoidance
Wild	Buffers	1230	0.209	0.21	0.196 = $P = 0.223$	Proportion
Wild	Forest	2830	0.31	0.482	0.466 = $P = 0.498$	Preference
Wild	Lowland	0	0.051	0	0 = $P = 0$	Avoidance

^a Z statistical test used in Neu et al. (1974) utilization-availability procedure with $\alpha = 0.05$.

Home Range And Habitat-Use

Pen-raised and wild/pen quail did not differ in estimated home range size for all seasonal periods, except 1996 overwinter season, possibly due to the lower percentage of mixed coveys (i.e. covey comprised of both one radio-tagged pen-raised or wild/pen quail) reported between years (33% vs. 36%). These percentages, however, may not truly indicate total mixing of coveys because of the low sample size of radio-tagged pen-raised quail in comparison to the total release (80 to ~8700 pen-raised quail). An important trend that we observed during night-netting attempts was that no “purely” wild covey was captured on PR throughout the entire study period. Wild/pen and pen-raised quail habitat-use analysis resulted in similar selection/avoidance patterns between treatment groups, indicating that home range size may be related to habitat-utilization. Supplemental feeding on PR may have decreased wild/pen and pen-raised quail home ranges during 1996 overwinter

season; however, larger home range sizes were reported for wild quail during 1997 overwinter season when feeding practices were equalized between study sites. The lack of significance in home range sizes for 1997 overwinter season (wild/pen vs. wild quail) may have been affected by the loss of tracking data from September to October. Behavioral characteristics such as movement and habitat selection within a covey are not fully understood; however, pen-raised quail seem to have altered these characteristics for the tested wild/pen quail population.

Linear Dispersal

Pen-raised quail appeared to be more stable in the utilization of their summer habitat compared to wild quail and did very little “range shifting” throughout the breeding season. Linear distances (pooled) were the smallest for pen-raised quail during both the breeding season ($\bar{x} = 628.4$ m) and overwinter season ($\bar{x} = 399.4$ m). Wild/pen quail had linear dispersal distances more similar to pen-raised

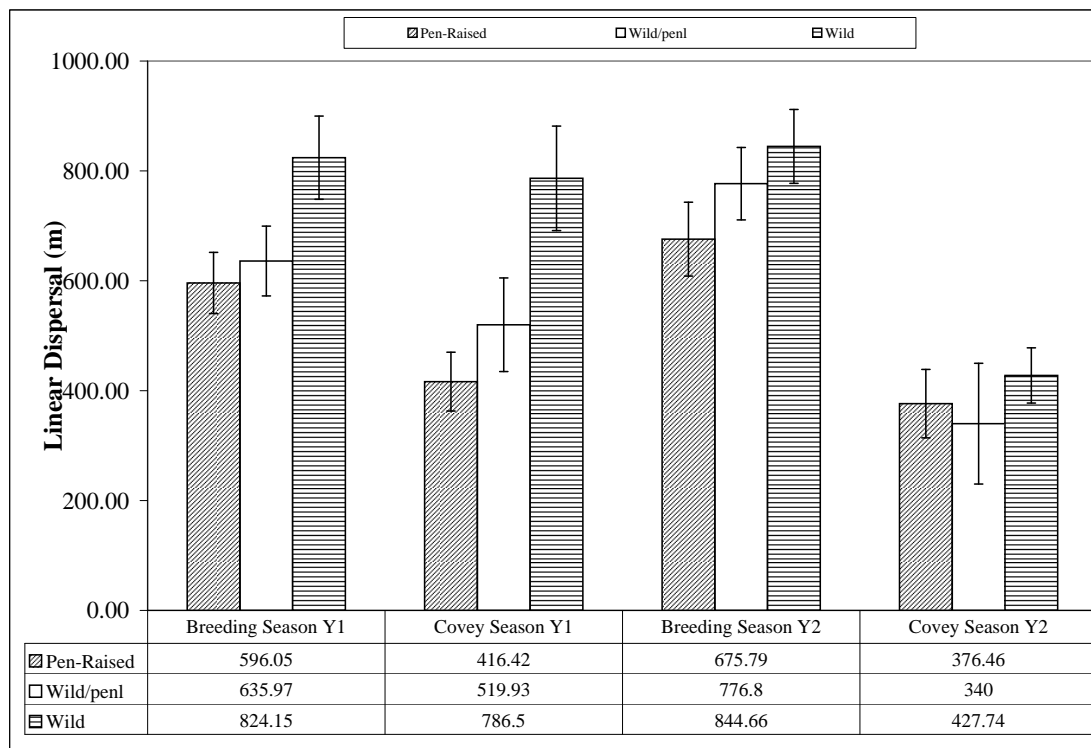


Figure 6: Linear dispersal distances (meters) for treatment groups on Groton Plantation, Allendale, SC during two seasonal groups (overwinter and breeding season) for both study years. Error bars represent the standard error of the treatment mean.

than wild quail, which may be due to their social interactions with pen-raised quail. No pen-raised quail were observed to transverse the 2,414 m buffer zone between research sites; however, six pen-raised quail were trapped on WC after release approximately 1,400 m away from the wild control site.

Nesting/Reproductive Success

Nesting success and predation varied between treatment groups and years, but due to low sample sizes (pen, $n = 9$; wild/pen, $n = 11$; wild, $n = 11$) per year, no conclusive trends can be interfered from these data. Therefore, it is still unclear whether or not pen-raised quail negatively affect native wild quail during breeding attempts and no substantiated data exists on the ecology of offspring from liberated pen-raised and wild quail raised by either a native or pen-raised quail.

Hunting Harvest On Pre-Season Release Sites

Hunting pressure for the three different hunting seasons did not vary greatly by year (541, 461 and 557 hr. hunted); however, the ratio of wild quail harvested per year on the PR site decreased dramatically between each of the three consecutive hunting seasons (1.95, 1.36 and 0.959). The result of lower wild/pen quail harvest rates per hunting season could be due to additive factors such as increased vulnerability to hunter harvest and increases in predation dynamics. However, these data do not justify population estimates or trends due to potential sampling errors such as non-representative harvesting of the "true" quail population that may include hunter avoidance characteristics, habitat selection, flushing and flight patterns, acclimation to feeding sites, loss leg bands, and other factors. Sisson et al. (2000a) reported lower survival rates of wild quail on pre-

Table 3: Nesting season data for radio-tagged treatment groups on Groton Plantation, Allendale County, South Carolina for the 1996 and 1997 breeding season.

	Pen-raised		Wild/pen		Wild	
	1996	1997	1996	1997	1996	1997
Hens alive on 6/1	12	8	6	14	7	13
Nests Located	9	9	6	16	10	12
Successful Nests	4	2	4	5	5	2
Avg. Clutch Size	11.4	15.5	11	13	12.5	13
Percent Hatch	97%	97%	94%	94%	96%	81%
Hen to Successful Nest Ratio	33%	25%	67%	36%	71%	15%
Nests Depredated	3	5	1	5	3	5
Nest Abandoned	1	0	1	2	2	3
Nesting Bird Predation	1	2	0	4	0	2

Table 4: Hunter harvest records from Groton Plantation, Allendale County, SC for combined pre-season release sites during three consecutive hunting seasons.

	1996-97	1997-98	1998-99
Hunting Days per Season	133	92	121
Wild Quail Harvested	259	125	116
Pen-raised Quail Harvested	1747	1532	2093
Wild to Pen-raised Quail Ratio	0.191	0.109	0.059
Avg. Wild Quail Harvested ^a	1.95	1.36	0.959
Avg. Pen-raised Quail Harvested ^a	13.14	16.65	17.3

^a Average Harvest Rate Per Hunting Attempt.

season release sites with hunting pressure; however, again there was no causative link between the release of pen-raised quail and lower survival rates of native quail.

Management Implications

Based on this study, data on survival rates and hunter harvest limitedly indicate that pre-season release programs intended for augmenting hunting populations could potentially affect native quail populations on these sites. Susceptibility to hunting, reduced home range size, changes in habitat

selection, and predation factors may be key factors in determining why wild quail populations are decreasing on areas with large-scale pre-season release programs; however, this hypothesis still needs extensive examination before a substantial conclusion can be validated. Linear buffer distances between pre-season release sites and wild control sites may be critical to sustaining large native wild quail populations. Based on our observations, we suggest that a linear buffer distances between 1,400 and 2,400 m may be required to effectively limit interactions between wild and pen-raised quail.

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