National Quail Symposium Proceedings

Manuscript 1599

Survival, Movement, and Habitat Use of Translocated Northern Bobwhite in Texas

Ricardo Cagigal Perez

Nova J. Silvy

Brian L. Pierce

Therese A. Catanach

SURVIVAL, MOVEMENT, AND HABITAT USE OF TRANSLOCATED NORTHERN BOBWHITE IN TEXAS

Ricardo Cagigal Perez
Department of Rangeland, Wildlife, and Fisheries Management, Texas A&M University, 2138 TAMU, College Station, TX 77843, USA

Nova J. Silvy[1]
Department of Rangeland, Wildlife, and Fisheries Management, Texas A&M University, 2138 TAMU, College Station, TX 77843, USA

Brian L. Pierce
Natural Resources Institute, Texas A&M University, 2260 TAMU, College Station, TX 77843, USA

Therese A. Catanach
Department of Rangeland, Wildlife, and Fisheries Management, Texas A&M University, 2138 TAMU, College Station, TX 77843, USA

Roel R. Lopez
Natural Resources Institute, Texas A&M University, 2260 TAMU, College Station, TX 77843, USA

Fred E. Smeins
Department of Ecology and Conservation Biology, Texas A&M University, 2258 TAMU, College Station, TX 77843, USA

ABSTRACT

For decades there has been a noticeable decline in northern bobwhite (*Colinus virginianus*; hereafter, bobwhite) populations. Few studies have assessed the survival of translocated bobwhite. We evaluated the effectiveness of reintroduction of bobwhite into the Texas (USA) Parks and Wildlife Department's Gus Engeling Wildlife Management Area (GEWMA), where they had been extirpated but now have suitable habitat. Before reintroduction, GEWMA was surveyed (spring call counts) to make sure no bobwhite were present. Forty-six bobwhite were trapped from March–April 2019 in South Texas, banded, bled, radio-tagged, transported to GEWMA, and released. In addition, 17 bobwhite were trapped banded, bled, radio-tagged, and released back into the source population as a control for comparison of movements, reproduction, and survival estimate differences between the source and released bobwhite populations. During July 2019, 3 broods (24 bobwhite) were trapped and translocated from a South Texas ranch to the GEWMA. Survival for bobwhite released at GEWMA was 37.0% through 1 July 2019 and 70.6% for bobwhite left on the ranch in South Texas. Three nests were found at GEWMA while none were found on the ranch in South Texas. Movement distances between daily locations for males and females did not differ at GEWMA or at the ranch in South Texas; however, there was a significant ($P \leq 0.001$) difference in daily movement for bobwhite at GEWMA and the South Texas ranch. Female bobwhite at GEWMA moved 5.4 times the distance of female bobwhite in South Texas and male bobwhite at GEWMA moved 5.9 times the distance of male bobwhite in South Texas. Bobwhite at GEWMA were located in woody cover only 24.2% of the time, whereas bobwhite in South Texas were located in woody cover 76.1% of the time. The greater daily movement and less use of woody cover for bobwhite at GEWMA probably contributed to their lower survival.

Citation: Cagigal Perez, R., N. J. Silvy, B. L. Pierce, T. A. Catanach, R. R. Lopez, and F. E. Smeins. 2022. Survival, movement, and habitat use of translocated northern bobwhite in Texas. National Quail Symposium Proceedings 9:107–114. https://doi.org/10.7290/nqsp09EldV

Key words: *Colinus virginianus*, habitat use, movements, northern bobwhite, reproduction, survival, Texas, translocation

[1] *E-mail: n-silvy@tamu.edu*

Northern bobwhite (*Colinus virginianus*; hereafter bobwhite) population declines have been acknowledged since the 1930s in Texas, USA and widespread declines across their historical range have been documented since the 1960s (Brennan 1991). Range-wide population decreases have been attributed to a variety of factors, including nonnative species such as red imported fire ants (*Solenopsis invicta*) and feral hogs (*Sus scrofa*) and weather events such as drought (Bridges et al. 2001), ice storms or heavy snow (Chavarria et al. 2012), and flooding events (Perotto-Baldivieso et al. 2011, Caldwell 2015). The 2 major reasons generally given by bobwhite biologists for the decline of bobwhite in Texas are lack of habitat and habitat fragmentation (Hernández and Peterson 2007). As bobwhite become isolated in fragmented populations, these small populations become vulnerable to local extinction through the occurrence of catastrophic events (Roseberry 1962). However, few if any management programs can completely offset the effects of catastrophic weather events. Although creation of favorable habitat can mitigate the impact of extreme weather events on bobwhite, these interventions are often prohibitively expense to undertake at a large scale.

As bobwhite have declined for decades across much of their range, local, regional, and statewide extinctions have occurred (Martin et al. 2017). Because of successful translocations of other gallinaceous birds, bobwhite enthusiasts increasingly call for use of the approach (Martin et al. 2017). Martin et al. (2017) concluded that bobwhite translocations were not a panacea for broad-scale restoration of bobwhite but stated the technique should remain at the forefront of bobwhite science so that a practical and reliable solution could be developed. Translocation can be used to supplement low-density bobwhite populations in some areas (Liu et al. 2000, 2002; Sisson et al. 2017) or to reestablish populations where bobwhite were extinct (Coppola et al. 2020).

The International Union for Conservation of Nature (IUCN) "Guidelines for the Re-introduction of Galliformes for Conservation Purposes" recommends defining success in 3 phases: 1) the survival of founders, 2) evidence of breeding by founders, and 3) long-term persistence of the translocated population (World Pheasant Association and IUCN/SSC Re-introduction Specialist Group 2009). Short-term goals may include survival of translocated bobwhite and successful reproduction. Long-term goals would include the persistence and growth of the population, to the point that it becomes self-sustaining and could withstand hunter harvest without significant reduction of the population size. This long-term condition defines the ultimate success for bobwhite population restoration.

Reintroduction of bobwhite entails the release of bobwhite into an area that was once part of its range, but from which it has since been extirpated (Seddon 2010, IUCN/SSC 2013). Dispersal from the release site has been observed in several translocations of gallinaceous birds (Lawrence and Silvy 1987, Coppola et al. 2020). Translocated sage grouse (*Centrocercus urophasianus*) also had increased movement, which led to lower survival (Baxter et al. 2008). Further complicating analysis, many of the bobwhite translocation studies (Liu et al. 2000, 2002; Terhune et al. 2010; Downey et al. 2017; Sisson et al. 2017) have released bobwhite into areas where current populations of bobwhite exist, making it difficult to measure the success of the translocation attempt.

There are a few examples of reintroductions of bobwhite in Texas (Liu et al. 2000, 2002), but no examples of long-term successful reintroductions of bobwhite in Texas. A major limitation to reintroductions of bobwhite in Texas is the difficulty in obtaining birds from appropriate (i.e., wild-caught individuals from similar habitats to the release area) source populations. Historically, few private landowners in Texas have been willing to allow wildlife managers access to their property to obtain birds, but it may be possible to obtain bobwhite from Texas wildlife management areas.

We assessed the survival of translocated bobwhite from South Texas to the Texas Parks and Wildlife Department's Gus Engeling Wildlife Management Area (GEWMA) to evaluate the feasibility of reintroducing and establishing a stable and self-sustainable population into areas where there are no longer bobwhite, but where the habitat was suitable for them. Our objectives were to 1) determine the survivability of reintroduced bobwhite, 2) compare nesting and brooding success between source and release populations, and 3) compare movements and habitat used by source site and reintroduced bobwhite.

STUDY AREA

Research was conducted from March 2019 through December 2019. Initially, this was to be a 2-year project, but the State of Texas would not allow travel during 2020 due to the coronavirus pandemic. Bobwhite were trapped in 3 different sites (Los Lazos Ranch, a Carrizo Springs ranch, and Santa Rita Ranch) for translocation (source sites) and then translocated to the reintroduction site, GEWMA. Los Lazos Ranch was located in the vicinity of the small community of Aguilares, Texas, about 48.3 km east from the border city of Laredo, Texas. This 145.7-ha ranch was in a predominantly arid region that contained mostly sandy clay loam and series of very deep, well-drained soils (U.S. Department of Agriculture 2010). The vegetation consisted of native brush, as well as native grasses, cacti, and buffelgrass (*Cenchrus ciliaris*). The ranch was used predominantly for white-tailed deer (*Odocoileus virginianus*) hunting, with no specific management plan except for corn feeding. Outside the hunting season, the ranch supported 20 head of cattle, which were restricted to a 129.5-ha area and had supplemental feeding and water troughs.

The other 2 source sites were a ranch near Carrizo Springs, Texas and the Santa Rita Ranch, located on the county line dividing Webb and Zapata counties southeast of Laredo (Figure 1). Both ranches were in a predominantly aridic region that contained mostly sandy clay loam and series of very deep, well-drained soils (U.S. Department of Agriculture 2010). The vegetation consisted of native brush, as well as native grasses, cacti, and buffelgrass. Both ranches were used predominantly for white-tailed deer hunting, The Santa Rita Ranch was an

80.9-ha low-fence ranch and had an effective control program for hogs and other predators.

The bobwhite reintroduction site (GEWMA) was a 4,435.5-ha area managed by the Texas Parks and Wildlife Department and was located near Tennessee Colony, Texas about 708 km northeast of the extraction locations (Figure 2). Several areas were being restored to bobwhite habitat. In these areas, the department had thinned post oak (*Quercus stellata*) trees or cleared the land of all trees. In all areas being restored for bobwhite, yaupon (*Ilex vomitoria*) was removed from the understory and little bluestem (*Schizachyrium scoparium*) grasses were reestablished to return these areas to their original native state. We selected an approximately 100-ha area being managed for bobwhite in the middle of GEWMA to release translocated bobwhite. A major difference between the source sites and GEWMA was soil type; the source sites were sandy clay loam, whereas GEWMA consisted of mostly light colored, rapidly permeable sands on the uplands. Prior to reintroduction, GEWMA was surveyed (spring call counts) to make sure no bobwhite were present.

Precipitation data for all study areas were obtained from U.S. Climate Data (2020). Precipitation during 2018 at the Los Lazos Ranch was below normal (53.6 cm) until September (Figure 3). With lack of precipitation during the normal bobwhite breeding season (May–July) bobwhite at the Los Lazos Ranch probably did not nest until September 2018 after the heavy rains that month. In 2019, monthly precipitation was closer to normal (Figure 3) and nesting started in May and continued through July 2019. Precipitation at the Santa Rita Ranch was probably similar to that of the Los Lazos Ranch due to their proximity to each other and to Laredo, Texas (the nearest weather station to both ranches).

Precipitation during 2018 at the Carrizo Springs ranch was below normal (yearly average was 50.1 cm) and similar to that of the Los Lazos Ranch. Rainfall at Carrizo Springs (Figure 4) from January–June 2018 (13.3 cm) and from July–August 2019 (21.5 cm) was close to normal for those periods.

Precipitation (yearly normal 111.3 cm) at GEWMA during 2018 averaged only 4.8 cm/month from January through June 2018 but averaged 8.6 cm/month from July through December 2018. During the same periods in 2019, GEWMA averaged 18.5 cm/month and 4.1 cm/month, respectively. A freeze (-5.6° C) on 7 March 2019 killed and then delayed forb production even with the abundant early rainfall.

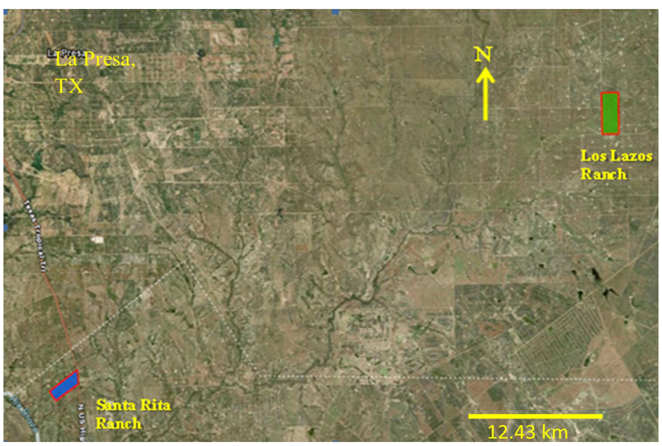

Fig. 1. Map location of Santa Rita Ranch (blue) in reference to Los Lazos Ranch (green), Texas, USA.

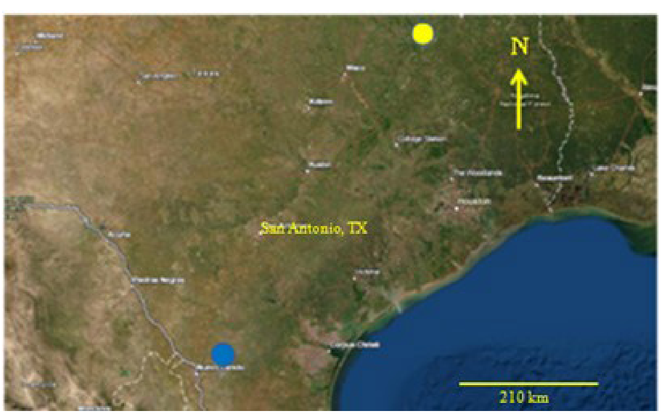

Fig. 2. Map location of Santa Rita Ranch (blue) in reference to Gus Engeling Wildlife Management Area (yellow), Texas, USA.

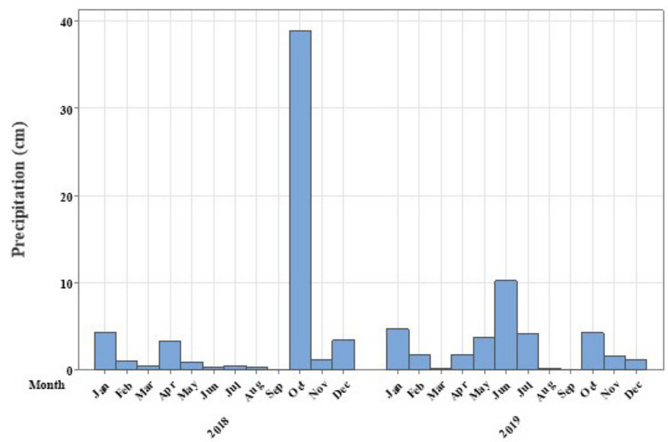

Fig. 3. Monthly precipitation (cm) totals for Laredo, Texas, USA during 2018 and 2019 (U.S. Climate Data 2020).

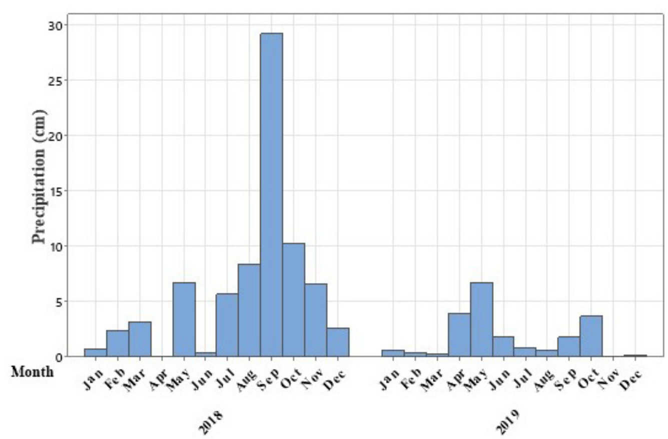

Fig. 4. Monthly precipitation (cm) totals for Carrizo Springs, Texas, USA during 2018 and 2019 (U.S. Climate Data 2020).

METHODS

Trapping and Marking

Trap sites were selected based on bobwhite sightings. Where we observed little or no bait disturbance between trapping days, we replaced those unproductive sites with new sites that had potential for successfully trapping bobwhite. Trap sites were baited regularly with commercial bird seed (Royal Wing Classic Mix Wild Bird Food, Tractor Supply, College Station, TX) starting in February so that when trapping was conducted (Mar–Aug 2019), bobwhite were already aware of these areas with readily available food and had become accustomed to frequenting the baited sites. Each trap location was supplied with approximately 0.5 kg of mixed grains including cracked corn, millet, milo, and black-oil sunflower seed once a week for the month leading up to trap placement. The use of a variety of grains for bait rather than using a single grain type allowed the bobwhite to selectively eat first the more palatable grains then gradually consume the less preferable grains, resulting in consistent access to a food source, even when the bait sites had been heavily utilized.

Bobwhite were trapped using Kniffin modified funnel traps (Reeves et al. 1968), a walk-in style trap similar to that originally described by Stoddard (1946) for trapping bobwhite. Traps were placed at the prebaited sites and baited with about 0.5 kg of mixed grains. Traps were checked once an hour to process captured animals. All bobwhite trapped were aged by primary covert color, sexed by head color (Lyons et al. 2020), weighed, and banded with a size 7 silver-colored band (National Band and Tag Company, Newport, KY, USA) on the right leg. Nontarget species captured were released and a tally was kept each trap day by species. Birds to be translocated were provided food and water while kept in a cardboard poultry container at room temperature and held for no more than 36 hours. Birds were transported by vehicle to GEWMA for release.

Bobwhite trapped at the source sites were fitted with an 8.8 g VHF (approximately 4% body weight) radio-transmitter with a mortality signal (150 MHz; Wildlife Materials, Carbondale, IL, USA; Figure 5) and bled for further genetic studies. Radio-tagged bobwhite were either translocated to GEWMA or released at the trap site. All radio-tagged bobwhite were monitored daily from March–July 2019 with each bird being located twice daily (morning and afternoon) using a handheld Yagi antenna to determine general location, movement, and survival status.

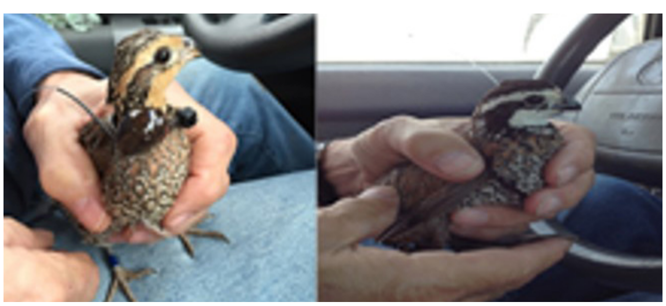

Fig. 5. Female bobwhite (left) fitted with bib-type radio-transmitter attached with zip tie. Before release, feathers are pulled through the zip tie to conceal the transmitter (male at right).

Bobwhite Survival

We estimated bobwhite survival using the nonparametric Kaplan-Meier estimation method (Distribution Overview Plot with **r**ight **c**ensoring, Minitab Statistical Software Package, 2019). We captured bobwhite from March through August and analyzed survival as a function of days since capture by entering the elapsed days at which individuals died or remained alive at the end of 100 days. We plotted survival and 95% confidence intervals as a function of days since survival and compared mean days of survival between groups with a log-rank Chi-square test. Because of the 7 March 2019 freeze at GEWMA and our observed lack of forbs following the freeze and insects, we compared survival of the first 12 radio-tagged bobwhite released (7–15 Mar 2019) at GEWMA to the second 12 radio-tagged bobwhite released (16–20 Mar 2019) on GEWMA for 100 days. By the time the second 12 bobwhite were released, small forbs where available as a bobwhite food source. We also compared survival for radio-tagged bobwhite left on the Los Lazos Ranch in South Texas and for radio-tagged bobwhite translocated to the GEWMA for 100 days.

Bobwhite Movements

To determine whether translocated bobwhite displayed movement similar to individuals from the source population, we plotted daily locations of radio-tagged bobwhite on base maps of the source and translocated study areas. We then measured the distance between successive daily locations of male and female bobwhite to obtain a mean-daily-movement distance (Silvy 1967, Robel et al. 1970) for the source and translocated populations. These mean-daily-movement distances for males and females from the source and translocated populations were then compared using a Student's *t*-test (Ott and Longnecker 2016) to determine whether they differed significantly.

Bobwhite Habitat Use

Vegetation types (grass, brush, and trees) on the Los Lazos Ranch and GEWMA were documented from aerial photographs (ground-truthed by personnel on the areas) and then compared to determine whether these vegetation types were used similarly by the source and translocated populations of radio-tagged bobwhite. We used a Chi-square test (Ott and Longnecker 2016) to determine whether vegetation type used by bobwhite was random or was being selected for at each area. To do this, each radio-tagged bobwhite at the Los Lazos Ranch and at GEWMA was located daily to determine location within a vegetation type. Vegetation-type use data were then compared for bobwhite left at the Los Lazos Ranch and bobwhite at GEWMA using a Chi-square test (Ott and Longnecker 2016) to quantify the use of grass, brush, and trees.

Bobwhite Reproduction

Radio-collared females at GEWMA were tracked with a handheld Yagi antenna ≥4 times/week. We walked in on female bobwhite once they had been found in the same location for 3–4 consecutive tracking sessions to determine whether the female was on a nest, and we took care to avoid flushing the female. If the female was found to be on a nest, a piece of flagging tape was tied to tall vegetation at least 10 m from the nest. This step allowed nests to be relocated once they hatched or were destroyed without attracting potential predators to the area. Once nesting, females were tracked 1–2 times daily and once a female was located off the nest for 3–4 consecutive tracking sessions, the nest was checked to determine whether the nest had hatched or failed.

For successful nests, we took notes on the location of the nest, the number of hatched eggs, the number of unhatched eggs, and the date of hatch. For unsuccessful nests, we noted location of the nest, the reason for failure, the number of unhatched or destroyed eggs, if possible to determine, and the date that it was destroyed. If a nest was successful, the female and brood were tracked twice daily and the number of chicks surviving in the brood was recorded if a female and brood were sighted along a road. Any transmitter that emitted a mortality signal was checked immediately. If a transmitter was recovered, the site was examined for probable cause of mortality (e.g., a pile of bobwhite feathers with a transmitter showing cuts in the rubber surrounding the antenna would indicate mortality by a raptor) and the female was then listed as deceased. A brood was considered to have survived if at least 1 chick remained at 3 weeks of age.

RESULTS

Trapping and Marking

Sixty-nine bobwhite, of which 62 were radio-tagged, were translocated to GEWMA. From 7 March–15 July, 33 bobwhite (9 adult males, 10 juvenile males, 2 adult females, and 12 juvenile females) were trapped and translocated from Los Lazos Ranch to GEWMA. During 17–20 March an additional 12 bobwhite (7 adult males, 1 juvenile male, 1 adult female, and 3 juvenile females) were translocated from Carrizo Springs to GEWMA. From 14–26 April 2019, 9 male (7 adults and 2 juveniles) and 8 female (6 adults and 2 juveniles) bobwhite were trapped, radio-tagged, and released at the Los Lazos Ranch. Last, 3 broods (24 bobwhite [4 adult males, 6 juvenile males, 2 adult females, and 12 juvenile females]) were trapped from 15–20 July and translocated from Santa Rita Ranch to GEWMA. Juvenile bobwhite in each brood were approximately ¾ adult size and were sexed by head coloration (Lyons et al. 2020). All adult bobwhite were radio-tagged when released at GEWMA; however, because of a shortage of transmitters, only 2 juvenile females were radio-tagged before release.

Bobwhite Survival

Ten of the first 12 bobwhite released at GEWMA were mortalities during the first 100 days, whereas 11 of the second 12 bobwhite released were mortalities during the first 100 days. However, the mean days of survival for the first 12 bobwhite released (7–16 Mar 2019) at GEWMA was 24.5 (± 9.59 SE) days through 100 days, whereas the mean days of survival for the second 12 bobwhite released (17–25 Mar 2019) was 54.2 (± 10.04 SE) days through 100 days (Figure 6); however, this difference was not significant ($X^2 = 2.062$, $df = 1$, $P = 0.151$).

Of the 45 bobwhite released at GEWMA, 33 were mortalities during the first 100 days. Of the 17 bobwhite trapped and released back on their capture site on the Los Lazos Ranch, only 5 were mortalities during the first 100 days. The mean days of survival for 45 bobwhite released at GEWMA was 50.4 (± 5.85 SE) days through 100 days compared to 76.0 (± 9.18 SE) days for 17 bobwhite left on the Los Lazos Ranch in South Texas (Figure 7); this difference was significant ($X^2 = 8{,}089$, $df = 1$, $P = 0.004$).

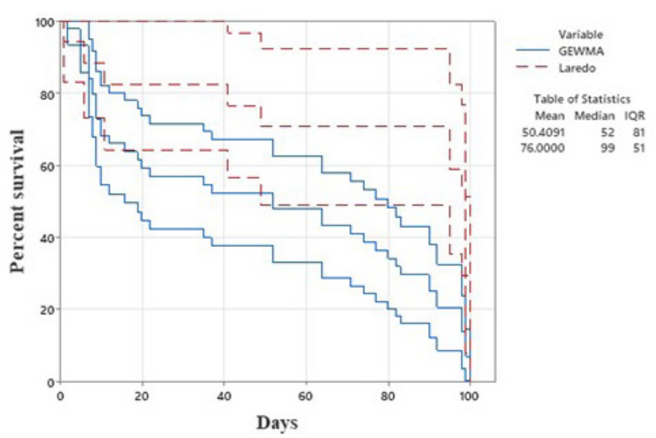

Fig. 6. Percent survival and 95% confidence interval and mean and median survival days for the first 12 bobwhite compared to the second 12 bobwhite released at Gus Engeling Wildlife Management Area, Texas, USA.

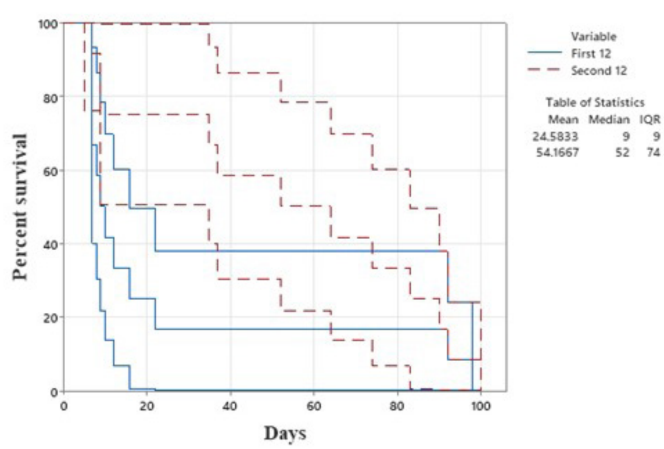

Fig. 7. Percent survival and 95% confidence interval and mean and median survival days of northern bobwhite from the source population (South Texas, USA) compared with the translocated population (Gus Engeling Wildlife Management Area, Texas).

Bobwhite Movements

Distances between daily locations for male (348 ± 84 SD) and female (270 ± 48 SD) bobwhite at GEWMA nor did male (59 ± 11 SD) and female (50 ± 11 SD) bobwhite distances between daily locations differ at the Los Lazos Ranch; however, there was a significant ($P < 0.001$) difference in daily movement for bobwhite at GEWMA and the ranch. Female bobwhite at GEWMA moved 5.4 times the distance of female bobwhite at Los Lazos Ranch and male bobwhite at GEWMA moved 5.9 times the distance of male bobwhite at the Los Lazos Ranch (Table 1).

Habitat Use

Bobwhite at GEWMA used the grass vegetation type more (75.8%) than was available (16.5%) and used the brush and tree vegetation types less than expected (Table 2). These differences were significant ($X^2 = 434.6416$, $n = 372$, $df = 2$, $P = 0.00001$). Bobwhite at GEWMA were located in woody cover only 24.2% of the time, whereas bobwhite at Los Lazos Ranch were located in woody cover 76.1% of the time (Table 2). Bobwhite at Los Lazos Ranch used the brush vegetation type more (76.1%) than expected (67.1%) and grass and trees less than expected (Table 2). These differences were significant ($X^2 = 6.8288$, $n = 403$, $df = 2$, $P = 0.032896$). Bobwhite at the GEWMA were located most often in areas dominated by little bluestem. Most bobwhite mortalities at the GEWMA were located in or near areas dominated by post oak trees.

Table 1. Mean distance traveled (m) between consecutive daily locations by northern bobwhite (*Colinus virginianus*) by age and sex at Gus Engeling Wildlife Management Area (GEWMA) in Texas, USA, and Laredo, Texas during July 2019.

Age/Sex[a]	Location	*n*	Mean	Standard deviation
AM	GEWMA	5	307	73
JM	GEWMA	2	451	113
All males	GEWMA	7	348	84
AF	GEWMA	2	217	37
JF	GEWMA	4	297	53
All females	GEWMA	6	270	48
AM	Laredo	5	57	9
JM	Laredo	1	66	22
All males	Laredo	6	59	11
AF	Laredo	4	49	10
JF	Laredo	2	53	13
All females	Laredo	6	50	11

[a] A: adult, J: juvenile, M: male, F: female.

Table 2. The percentage of bobwhite (*Colinus virginianus*) locations within 3 vegetation types on the Gus Engeling Wildlife Management Area (GEWMA) and a private ranch near Laredo, Texas, USA, during July 2019. Numbers in parentheses are the percentage of cover of each vegetation type on the study areas. Roads, ponds, and oil-well pads composed 2.8% of the Laredo ranch.

Area	*n*	Vegetation type		
		% Grass	% Brush	% Trees
GEWMA	12	75.8(16.5)	21.2(5.7)	3.0(77.8)
Laredo	13	23.9(28.9)	76.1(67.1)	0.0(1.2)

Reproduction

No bobwhite nests were located at the Los Lazos Ranch; however, 3 bobwhite nests were located at GEWMA. The first nest was located on 30 May 2019 and at that time contained 8 eggs and later 12 eggs. Feral hogs destroyed this nest on 3 June 2019. A second nest was located on 4 June 2019 and contained at least 13 eggs; it was destroyed by an unknown cause. The third nest, located on 14 June 2019, contained 15 eggs. This nest was destroyed on 17 June 2019 by a snake (3 eggs still in nest). All nests located at GEWMA were located in little bluestem clumps.

DISCUSSION

The lower survival of the first 12 radio-tagged bobwhite released on 7 March 2019 at GEWMA compared to the survival of the next 12 radio-tagged bobwhite released on 17 March 2019 was probably due to the lack of available food (forbs and the insects that feed on them) caused by the 7 March 2019 freeze. During this same time-period, availability of forbs and insects was not a problem on the South Texas ranches where bobwhite were trapped. Osborne (1993) suspected radio-transmitters on released bobwhite caused mortality. However, all bobwhite in our study were fitted with radio-transmitters; therefore, any additional mortality caused by the radio-transmitters should have been similar for the 2 populations. Scott et al. (2012), collaborating with the Texas Parks and Wildlife Department, translocated 550 bobwhite to 2 sites during 2004–2006. Radio-tagged, translocated bobwhite had lower (35%) survival compared to residents (56%). Scott et al. (2012) speculated that restoring bobwhite populations in fragmented landscapes with a few remaining declining bobwhite populations might be impractical.

The mean days of survival for 45 bobwhite released at GEWMA was 50.4 days, similar to a report by Downey et al. (2017). They translocated 409 wild bobwhite (186 radio-marked females) to supplement 2 sites in Shackelford and Stephens counties, Texas, during March 2013 and March 2014. Their spring–summer (Mar–Sep) survival ranged between 32% and 38%. Their translocation efforts failed to increase the bobwhite population beyond that of the control during this study. Downey et al. (2017) recommended that future translocation research should aim to increase translocation success by investigating methods for increasing survival during the first 4 weeks following translocation.

Although bobwhite on GEWMA moved more than those at the Los Lazos Ranch, movement was similar to that found by Terhune et al. (2006) for their translocated bobwhite in Georgia, USA. Bobwhite at GEWMA used limited areas (<100 ha) of suitable habitat. Bobwhite on GEWMA spent about

23.9% of the day in the grassland vegetation type. Terhune et al. (2010) suggested that 2 site-specific criteria should be met prior to instituting translocation. First, habitat management should be conducted to ensure that high-quality habitat exists. Second, the patch size should be ≥600 ha of high-quality habitat and poorer sites may warrant even larger patches. Both criteria were met at GEWMA as the release sites were managed for bobwhite reintroduction. Terhune et al. (2006) translocated bobwhite associated with other bobwhite present on their release area, which probably limited the movements of the translocated bobwhite.

Three of 5 (60%) juvenile bobwhite females translocated to GEWMA and still alive in June were able to establish and incubate nests. Of the 4 adult females translocated to GEWMA, none were observed to nest. Downey et al. (2017) reported that 74% of their translocated females that entered the nesting season produced a nest. They also found an apparent nest success of 46.1% and a nesting rate of 1.1 ± 0.1 (SE) nests per female. Scott et al. (2012) found the percentage of hens nesting (95% CI = 36 ± 16.4%) and nesting rate (95% CI = 1.1 ± 0.2 nests/hen) were lower for translocated bobwhite than for resident bobwhite (79 ± 12.4% and 1.6 ± 0.3 nests/hen, respectively).

MANAGEMENT IMPLICATIONS

Translocated bobwhite had greater daily movements than resident bobwhite. Because translocated bobwhite were introduced into a new habitat without any knowledge of available resources, we speculate that much of the movement can be attributed to searching for forage, nest sites, and shelter. We believe the translocation was somewhat successful as the translocated bobwhite attempted to nest and survival of the translocated bobwhite was similar to that of the bobwhite followed on the Los Lazos Ranch. Previous bobwhite translocation studies did not compare survival, reproduction, vegetation-type use, and movement of their translocated bobwhite to bobwhites followed at their source sites. Because we did so, results from our translocation shined a light on certain results that had been previously overlooked. For a bobwhite reintroduction to be fully successful (a self-sustaining population), founders should survive, founders should breed and produce young, and there should be long-term persistence of the translocated population. In addition, a larger number of bobwhite should be translocated and done so over several years for a successful translocation.

ACKNOWLEDGMENTS

First, we thank Dr. Jim Cathey for helping fund this project. Funding was provided through the Reversing the Quail Decline in Texas Initiative and the Upland Game Bird Stamp Fund based on a collaborative effort between Texas Parks and Wildlife Department and Texas A&M AgriLife Extension. We also would like to thank everyone who helped us with the project: Diego S. Navarro (student worker) and Kyle T. Hand, Kyle R. Brunson, Jeffrey W. Gunnels, Michael C. Frisbie, Jason B. Hardin, and Robert M. Perez (Texas Parks and Wildlife Department personnel).

LITERATURE CITED

Baxter, R. J., J. T. Flinders, and D. L. Mitchell. 2008. Survival, movements, and reproduction of translocated greater sagegrouse in Strawberry Valley, Utah. Journal of Wildlife Management 72:179–186.

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

Brennan, L. A., F. Hernandez, and D. Williford. 2014. Northern bobwhite (*Colinus virginianus*). In A. Poole, editor. The birds of North America online. Cornell Lab of Ornithology, Ithaca, New York, USA. <https://birdsoftheworld.org/bow/species/norbob/cur/introduction>. Accessed 14 Feb 2022.

Bridges, A. S., M. J. Peterson, N. J. Silvy, F. E. Smeins, and X. B. Wu. 2001. Differential influence of weather on regional quail abundance in Texas. Journal of Wildlife Management 65:10–18.

Caldwell, J. W. 2015. Use of *Extinguish Plus*™ to reduce red imported fire ants and increase northern bobwhite abundance. Thesis, Texas A&M University, College Station, USA.

Chavarria, P. M., A. Montoya, N. J. Silvy, and R. R. Lopez. 2012. Impact of inclement weather on overwinter mortality of Montezuma quail in southeast Arizona. Proceedings of the National Quail Symposium 7:346–351.

Coppola, P. M., K. R. Stevens, C. K. Williams, T. M. Terhune, J. P. Parke, and J. Cecil. 2020. Landscape connectivity influences survival and resource use following long-distance translocation of northern bobwhite. Journal of Wildlife Management 85:369–383.

Downey, M. C., D. Rollins, F. Hernández, D. B. Wester, and E. D. Grahmann. 2017. An evaluation of northern bobwhite translocation to restore populations. Journal of Wildlife Management 81:800–813.

Hernández, F., and M. J. Peterson. 2007. Northern bobwhite ecology and life history. Pages 40–46 *in* L. A. Brennan, editor. Texas quails: ecology and management. Texas A&M University Press, College Station, USA.

IUCN/SSC. 2013. Guidelines for reintroductions and other conservation translocations. Version 1.0. IUCN Species Survival Commission, Gland, Switzerland.

Lawrence, J. S., and N. J. Silvy. 1987. Movement and mortality of transplanted Attwater's prairie chickens. Journal of the World Pheasant Association 12:57–65.

Liu, X., R. M. Whiting, B. S. Mueller, D. S. Parsons, and D. R. Dietz. 2000. Survival and causes of mortality of relocated and resident northern bobwhites in East Texas. National Quail Symposium Proceedings 4:119–124.

Liu, X., R. M. Whiting, D. S. Parsons, and D. R. Dietz. 2002. Movement patterns of resident and relocated northern bobwhites in eastern Texas. National Quail Symposium Proceedings 5:168–172.

Lyons, E. K., M. A. Schroeder, and L. A. Robb. 2020. Criteria for sex and age of birds and mammals. Pages 200–221 *in* N. J. Silvy, editor. Wildlife techniques manual. Eighth edition. Volume I: research. Johns Hopkins University Press, Baltimore, Maryland, USA.

Martin, J. A., R. D. Applegate, T. V. Dailey, M. Downey, B. Emmerich, F. Hernández, M. M. McConnell, K. S. Reyna, D. Rollins, R. E. Ruzicka, and T. M. Terhune II. 2017. Translocation as a population restoration technique for northern bobwhites: a review and synthesis. National Quail Symposium Proceedings 8:1–16.

Osborne, D. A. 1993. Feasibility of transplanting wild northern bobwhite on Tri-County Fish and Wildlife Area in northern Indiana. Thesis, Purdue University, West Lafayette, Indiana, USA.

Ott, R. L., and M. Longnecker. 2016. An introduction to statistical methods and data analysis. Seventh edition. Cengage Learning, Boston, Massachusetts, USA.

Perotto-Baldivieso, H., X. B. Wu, M. J. Peterson, F. E. Smeins, N. J. Silvy, and T. W. Schwertner. 2011. Flooding-induced landscape changes along dendritic stream networks and implications for wildlife habitat. Landscape and Urban Planning 99:115–122.

Reeves, H. M., A. D. Geis, and F. C. Kniffen. 1968. Mourning dove capture and banding. Special scientific report: wildlife 117, U.S. Fish and Wildlife Service, Washington, D.C., USA.

Robel, R. J., J. N. Briggs, J. J. Cebula, N. J. Silvy, C. E. Viers, and P. G. Watt. 1970. Greater prairie chicken ranges, movements and habitat usage in Kansas. Journal of Wildlife Management 34:286–306.

Roseberry, J. L. 1962. Avian mortality in southern Illinois resulting from severe weather conditions. Ecology 43:739–740.

Scott, J. L., F. Hernández, L. A. Brennan, B. M. Ballard, M. Janis, and N. D. Forrester. 2012. Population demographics of translocated northern bobwhite on fragmented habitat. Wildlife Society Bulletin 37:168–176.

Seddon, P. J. 2010. From reintroduction to assisted colonization: moving along the conservation translocation spectrum. Restoration Ecology 18:796–802.

Silvy, N. J. 1967. Movements, monthly ranges, reproductive behavior, and mortality of radiotagged greater prairie chickens (*Tympanuchus cupido pinnatus*). Thesis, Kansas State University, Manhattan, USA.

Sisson, D. C., T. M. Terhune II, W. E. Palmer, and R. E. Thackston. 2017. Contributions of translocation to northern bobwhite population recovery. National Quail Symposium Proceedings 8:151–159.

Stoddard, H. L. 1946. The bobwhite quail: its habits, preservation and increase. Charles Scribner's Sons, New York, New York, USA.

Terhune, T. M., D. C. Sisson, W. E. Palmer, B. C. Faircloth, H. L. Stribline, and J. P. Carroll. 2010. Translocation to a fragmented landscape: survival, movement, and site fidelity of northern bobwhites. Ecological Applications 20:1040–1052.

Terhune, T. M., D. C. Sisson, H. L. Stribling, and J. P. Carroll. 2006. Home range, movement, and site fidelity of translocated northern bobwhite (*Colinus virginianus*) in southwest Georgia, USA. European Journal of Wildlife Research 52:119–124.

U.S. Climate Data. 2020. Version 3.0. <https://www.usclimatedata.com/>. Accessed 14 Feb 2022

U.S. Department of Agriculture. 2010. Aguilares series. National Cooperative Soil Survey. <https://soilseries.sc.egov.usda.gov/OSD_Docs/A/AGUILARES.html>. Accessed 14 Feb 2022.

World Pheasant Association and IUCN/SSC Re-introduction Specialist Group, editors. 2009. Guidelines for the re-introduction of Galliformes for conservation purposes. IUCN, Gland, Switzerland, and World Pheasant Association, Newcastle-upon-Tyne, United Kingdom.