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ABSTRACT

Scaled Quail (*Callipepla squamata*) populations have become locally extinct and spatially fragmented in the Rolling Plains ecoregion of Texas. Translocating Scaled Quail from core to declining populations could augment populations or re-establishing extinct populations. Although translocations of scaled quail have been attempted in Texas, none have been documented and none have attempted to identify best practices. Release strategy (i.e., hard or soft release) is a factor that can influence the success of a translocation. Our objective was to compare daily apparent survival of scaled quail translocated to the Rolling Plains between 2 release treatment groups: hard- and soft-release. We estimated a daily apparent survival rate (DASR) for radio-marked hens during the breeding season as a function of age, release treatment, and a time trend. We found evidence of a positive effect of the soft release treatment and higher DASR in adult hens. Overall, DASR of translocated hens was low compared to reported estimates of survival in established resident populations. Using a soft release strategy and translocating a greater proportion of adults may improve future translocation success for scaled quail.

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Key words: *Callipepla squamata*, dispersal, reintroduction, scaled quail, survival, translocation

INTRODUCTION

Scaled quail (*Callipepla squamata*) have declined by ~ 7% per year since 1966 in the Central Mixed Grass Prairie (Sauer et al. 2014), an area that includes the Rolling Plains Ecoregion of Texas and Oklahoma (Gould 1975). Concurrently, scaled quail core distribution shifted to include only the westernmost portion of their historic range leaving small isolated populations where they were once abundant in the Rolling Plains Ecoregion of Texas and southwestern Oklahoma (Sauer et al. 2014, Rollins 2007, Silvy et al. 2007). Scaled quail in the Rolling Plains experienced an abrupt decline in 1988 and have remained at low abundance since (Rollins 1997, 2007). Although scaled quail are capable of dispersing long distances (up to 70 km) in wet years (Campbell and Harris 1965), habitat fragmentation in the Rolling Plains ecoregion as a

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result of human activities (Bridges et al. 2002, Rho 2015) and prolonged drought (Lusk et al. 2007, McGregor 2015) may restrict these movements preventing recolonization or augmentation of remnant populations. Additionally, the characteristic 2–3 year boom and bust cycles exhibited by scaled quail do not occur at low densities causing isolated populations to decline without an influx of new individuals (Lusk et al. 2007).

Considering these factors, translocation of scaled quail from source areas could reestablish or increase remnant populations (Armstrong and Seddon 2008, Griffith et al. 1989). Translocation has been well researched as a tool for restoring northern bobwhites (*Colinus virginanus*) with success documented in the southeastern United States (Terhune et al. 2006a,b; 2010). Translocation of bobwhites to the Rolling Plains ecoregion was successful based on short-term survival and dispersal, but population monitoring 2-years post-release did not demonstrate an increase (Downey 2015). Populations of scaled quail have been established successfully outside their native range in east-central Washington and eastern Nevada, although neither of these efforts were well documented (Schemnitz et al. 2009).

Release strategy, whether hard or soft release, can impact the success of a translocation and these impacts are often species specific (Batson et al. 2005, Moseby et al. 2014). In general, social species with small home ranges benefit from a soft release because of an increase in site fidelity due to reduced homing instincts (Moseby et al. 2014). Quail translocations have employed both hard (Terhune et al. 2005, Downey 2015) and soft release strategies (Stephenson et al. 2011, Scott et al. 2013), but no studies have directly compared release techniques. A translocation program with wild-trapped scaled quail using a soft-release technique was conducted at the Rolling Plains Quail Research Ranch, Fisher County, Texas, and has been effective, at least in the short-term (Pers. Comm. D. Rollins, Rolling Plains Quail Research Ranch).

The long-term goal of a translocation is to establish a self-sustaining population (Griffith et al. 1989). In the short-term that goal is dependent on the initial survival, dispersal, and reproduction of the founding individuals on the release site (Terhune 2010). Our objective was to compare apparent survival of translocated scaled quail between two release treatment groups, hard and 4-week soft release, to determine the effectiveness of either method to guide future releases. Additionally, we wanted to document maximum distance dispersed, nest initiation, and nest success of translocated scaled quail.

STUDY AREA

The release site was Matador Wildlife Management Area (WMA) in the central Rolling Plains ecoregion in Cottle County, Texas. Matador WMA is an 11,400-ha property owned and managed by Texas Parks and Wildlife Department. It was purchased in 1959 for the stated purposes of wildlife research, wildlife management, and public use. Public use activities include camping, hiking, fishing, and hunting of white-tailed deer (*Odocoileus virginianus*), mule deer (*Odocoileus hemionus*), feral hogs (*Sus scrofa*), Rio Grande turkey (*Meleagris gallopavo intermedia),* dove (*Zenaida* and *Streptopelia* spp.), and northern bobwhite.

Average rainfall and snowfall on Matador WMA are 56 cm and 7 cm, respectively. Soils are comprised predominantly of Woodward and Quinlan loams, Hilgrave sandy gravelly loam, Yomont fine sandy loam, Devol loamy fine sand, and Miles fine sandy loam (Natural Resource Conservation Service 2015). Terrain on the WMA is slightly sloping sandy upland with rough broken land in drainages. Mesquite (*Prosopis glandulosa*), sand shinnery oak (*Quercus havardii*), and sandsage (*Artemisia filifolia*) are dominant woody plants on coarse-textured soils whereas redberry juniper (*Juniperus pinchotii*) dominates on finer-textured soils and breaks. Grasses are primarily gramas (*Bouteloua* spp.), sand dropseed (*Sporobolus cryptandrus*), silver bluestem (*Bothriochloa saccharoides*), and threeawns (*Aristida* spp.)

METHODS

We captured scaled quail from 3 locations using walk-in funnel traps (Stoddard 1931) baited with sorghum and covered with natural vegetation to reduce stress and mortality of captured birds. Quail were captured on the 3 different source locations in Sterling and Bailey Counties, Texas during an 8-day period (17– 24 March) in 2015. Each quail was leg-banded, weighed, and classified by age and sex. We assumed that quail captured in the same trap were in the same covey and attempted to keep coveys together for release. Each covey group was then randomly assigned a release treatment (i.e., hard- or soft-release). The females were fitted with a 6-g necklace style radio transmitter (American Wildlife Enterprises, Monticello, FL). We chose to collar females only for two reasons: 1) we were interested in documenting reproduction, and 2) females would presumably pair with released males resulting in dependent survival and dispersal among pairs (reducing our sample size). All quail were transported to the release site within 24 hours using a plastic quail carrier (GQF Manufacturing Company Inc., Savannah, Georgia) covered with a black sheet to reduce stress. Quail assigned to a hard-release treatment were released immediately upon arriving on site. Soft-release birds were placed in one of 3 holding pens similar to the commercially available Surrogator® (Wildlife Management Technologies, Wichita, KS). Each holding pen housed 12–15 translocated quail. All holding pens were stocked with food, in the form of layer ration and sorghum, and water which was available to the quail ad libitum. All soft-release quail were held for 3–4 weeks and were then released on the same day (22 April 2015). All trapping, handling, and marking of scaled quail was done in accordance with protocols approved by Texas A&M AgriLife Research Animal Care and Use Committee (AUP # 2013-004A) and with permission from Texas Parks and Wildlife (Scientific Research Permit No. SPR-0690-152).

Radio-marked hens were monitored daily for 159 days during the breeding season from 18 March to 25 August 2015. We recorded survival (i.e., live or dead), location, nesting status (i.e., currently incubating or not nesting), and nest fate (i.e., hatched, or failed). Locations were obtained by homing in on the hen and semi-circling it. We attempted to locate missing quail by searching for them on county roads adjacent to the WMA. Once a bird was located, we continued daily monitoring. We additionally searched for missing quail by flying transects spaced 2-km apart with a 20-km buffer around the Matador WMA on 24 June 2015.

Although we attempted to locate hens daily, the rough terrain and long dispersal distances relative to the range of the collar (<1 km) resulted in uneven monitoring intervals for most individuals and probability of detection < 1. Therefore, we estimated daily apparent survival rate (DASR) for radio-marked hens using Cormack-Jolly-Seber (CJS) models rather than known-fate models in Program MARK. CJS models allow for the estimation of apparent survival (i.e., the probability that the individual survives and stays on the study site) and detection. For all models we allowed detection to vary between two groups: 1) hens that we were able to monitor consistently until death or to the end of the monitoring period (i.e., high detection), and 2) hens that went missing during the monitoring period (i.e., low detection). The models we developed included 3 variables to describe variation in DASR.

1. *Age*.–We included age at capture as a categorical predictor to describe variation in DASR between subadults (<1 year old quail, hatched in the preceding summer) and adults (>1 year old quail). Although age has been shown to influence survival in resident bobwhite quail, Terhune et al. (2010) found no effect for translocated bobwhites. Therefore, we hypothesized that we would also find no influence of age in translocated scaled quail, particularly because subadult quail at the time of capture would likely be >8 months old.
2. *Release method*.–We hypothesized that DASR would be greater for quail in the soft-release treatment based on the supposition that the holding period would allow quail to recover from the stress of capture and transport, avoid the peak of raptor migrations, as well as decrease homing instincts (Batson et al. 2015, Downey 2015).
3. *Time Trend*.–We included a linear time trend to describe an increase or decrease in DASR over the monitoring period. Our hypothesis was that DASR would increase over the monitoring period as quail became more familiar with their surroundings.

We assessed relative support for each model using Akaike's Information Criterion with a correction for a small sample size (AIC_c). Candidate models included all combinations of factors as well as the null and global models. Models <2 ΔAIC_c's from the top model were considered competitive (Burnham and Anderson 2002). Within those competitive models, we evaluated the influence of each covariate using 80% confidence intervals of beta estimates (Arnold 2010). If the confidence interval overlapped zero we assumed the parameter was uninformative.

RESULTS

We trapped, banded, and translocated a total of 88 scaled quail to the Matador WMA during March 2015. This included 40 radio-marked hens, 47 males, and 1 unknown. Forty-two quail ($n = 17$ hens) were randomly assigned to a soft-release treatment and 46 ($n = 23$ hens) to a hard-release treatment. Overall, 73% ($n = 64$) quail were juveniles. Within the treatments, 81% ($n = 34$) and 65% ($n = 30$) of the soft- and hard-released quail, respectively, were juveniles. The discrepancy was due to variation in the number, age, and sex of quail captured on a particular day and our protocol to keep quail captured together in their covey units. Thirteen hens went missing permanently during the monitoring period: 3 (17%) soft and 10 (43%) hard released. We did not observe radio-marked hens coveyed with other hens after two days post release, therefore we assumed the fates of hens to be independent.

We observed the first hen nesting on 24 May 2015. At the time of nest initiation, 11 hens were missing from the study site (10 hard released) and 7 were observed dead (5 hard released). This made the effective sample size for nest initiation 8 and 14 hens for hard and soft release, respectively. We recorded 7 nests (1 hard released; 6 soft released); all were successful. The average clutch size was 12 eggs (range 8–15). Most nests were composed of multiple substrates. The most common nesting substrates were sand dropseed (N = 3) and prickly pear (N = 3, *Opuntia engelmannii*), but yucca (*Yucca* spp.), redberry juniper, broom snakeweed (*Gutierrezia sarothrae*), and plains bristlegrass (*Setaria vulpiseta*) were also used. Dispersal distances ranged from 0.5 to 22 km and averaged 6.7 km. Most hens (85%, $n = 34$) dispersed >2 km from their respective release point and 30% ($n = 12$) dispersed >10 km. The mean maximum distance dispersed by hard-released hens was 10.3 km (SD = 5.93) compared to 6.8 km (SD = 6.89) by soft-released hens.

Five models were within 2 ΔAICc of the top model and were considered competitive based on our *a priori* criteria (Table 1). These models included all three covariates describing DASR: age, release, and time trend. We interpreted 80% confidence intervals surrounding the beta estimate for each covariate from the model containing all three parameters. We found the confidence intervals for the covariate describing time trend to overlap zero indicating no measurable effect on DASR (Table 2). Covariates describing age and release showed a positive effect on DASR of soft over hard release and adult over juvenile hens, thus DASR of soft-released adult hens was highest ($\varphi = 0.99$, SE = 0.003) and DASR of hard released juvenile hens was lowest ($\varphi = 0.95$, SE = 0.01; Table 3). The estimated probability (P) of a soft-released adult versus juvenile hen surviving and not emigrating during the monitoring interval (159) was P = 0.33 and P = 0.08,

Table 1. Candidate model set describing apparent survival (φ) and detection (p) of translocated scaled quail at Matador Wildlife Management Area in the Rolling Plains Ecoregion of Texas during 2015. Covariates modeling apparent survival include age at capture (age), hard vs. soft release treatment (release), and a linear time trend (T). For all models we allowed detection to vary between two groups: 1) hens that we were able to monitor consistently until death or to the end of the monitoring period (i.e., high detection), and 2) hens that went missing during the monitoring period (i.e., low detection). Intercept only model included for comparison.

Model	AICc	Δ AICc	AICc Weight	k
φ (age + release), p (group)	1462.425	0	0.23089	5
φ (T), p (group)	1462.76	0.3411	0.19469	4
φ (release + T), p (group)	1462.84	0.4179	0.18735	5
φ (age + release + T) , p (group)	1463.04	0.6192	0.16941	6
φ (age + T), p (group)	1463.89	1.4711	0.11065	5
φ (release), p (group)	1464.04	1.6193	0.10275	4
φ (.), p (group)	1471.53	9.114	0.00242	3
φ (age), p (group)	1472.09	9.6691	0.00184	4
φ (.), p (.)	1507.85	45.425	0	2

respectively. Estimated probability of a hard-released adult versus juvenile hen surviving and not emigrating was $P = 0.03$ and $P < 0.01$, respectively.

DISCUSSION

Our data indicated a positive effect of the 4-week soft release treatment on DASR. No studies have directly compared release strategies when translocating quail, however several studies have employed a soft release technique in successful translocations of quails and other galliforms. Stephenson et al. (2011) held mountain quail (*Oreorytx pictus*) for 3-4 months prior to release and reported a successful translocation effort in terms of survival and reproduction. Scott et al. (2013) used a 7-day soft-release for northern bobwhites and reported no ill effects of the holding period. Rodgers (1992) documented a successful system for translocation of sharp-tailed grouse that involved holding wild-caught birds for up to 10 weeks prior to release. Many translocation efforts go unpublished. In an effort to capture this information, Snyder et al. (1999) used a questionnaire sent to wildlife biologists, managers, and researchers to report unpublished translocation attempts. They found that a soft release of prairie grouse species was positively correlated with translocation success.

In addition to the increase in DASR, the soft release technique also offers an advantage in terms of exposure to the environment (i.e. hens held in captivity are not subject to daily mortality). Scaled quail are most efficiently trapped from source populations before covey break-up which can occur as early as late-February. In our study, the first nest was detected in late May. Because we did not observe any mortality during the holding period for soft-release quail, this technique effectively protected translocated quail from natural mortality up to the time of release, roughly one month prior to nest initiation.

Although there was a positive effect of release treatment, the overall apparent survival of hens during breeding season in our study was low compared to other published survival rates of scaled quail. Rollins (2009) reported survival estimates of female scaled quail ranging from 0.67–0.80 and 0.22–0.48 in in Pecos and Brewster Counties, Texas (Trans Pecos ecoregion) and Sierra County, New Mexico, respectively. Survival documented by Pleasant et al. (2006) in Bailey County, Texas (High Plains Ecoregion) was 0.30–0.48. Both studies followed radio-marked female scaled quail during the breeding season from populations of resident, non-translocated birds. We would expect our estimates to be lower than true survival estimates (as apparent survival also includes the probability that the hen does not emigrate), however for 3 out of 4 groups apparent survival was <0.1.

Most hens dispersed >2 km from their respective release point. A distance that would exceed the typical home range size of 0.30–1.20 km^2 for scaled quail (Cantu et al. 2006). We observed 2 long distance movements of >20 km. These types of long distance dispersals have been documented in resident scaled quail populations, although they are thought to be infrequent (Campbell and

Table 2. Beta estimates and associated 80% confidence intervals (CIs) for juvenile vs. adult (age), hard vs. soft release treatment (release), and linear time trend (T) variables in models of apparent survival of translocated scaled quail at the Matador Wildlife Management Area in the Rolling Plains Ecoregion of Texas during 2015. For age and release the reference levels were juvenile and hard release, respectively.

Variables	Beta	SE	Lower CI	Upper CI
Release	0.81	0.48	0.20	1.43
Age	0.61	0.48	0.001	1.2
T	0.01	0.01	-0.01	0.02

Table 3. Estimates of daily apparent survival rates (DASR) and associated 95% confidence intervals (CIs) of scaled quail hens translocated using two release strategies. Hens were released at the Matador Wildlife Management Area in the Rolling Plains Ecoregion of Texas during 2015.

Release Strategey	Age	DASR	SE	Lower CI	Upper CI
Hard	Juvenile	0.95	0.01	0.92	0.97
	Adult	0.97	0.01	0.95	0.99
Soft	Juvenile	0.98	0.004	0.97	0.99
	Adult	0.99	0.003	0.98	0.99

Harris 1965, Cantu et al. 2006). It is important to note that one-third of the radio-collared hens went missing during our study period. Our probability of detecting radio-collared individuals was high on the WMA given our monitoring and search effort. Therefore, it is likely that these birds dispersed beyond our study area. As a result, the average dispersal distance for hard-release treatment is likely biased low because the missing hens were disproportionately from the hard-release treatment.

Our study is limited in scope and sample size, however it represents a novel attempt to assess the effects of differing release strategies and document a scaled quail translocation in the Rolling Plains ecoregion of Texas. We believe that future research efforts should attempt to document the short-term demographic parameters that we monitored at a minimum and potentially include males as well. If survival differs between sexes it may be advantageous for release groups to have a skewed sex ratio (in our study we attempted a to translocate males and females at 1:1). Long-term studies to document a population response pre- and post-translocation, as well as survival of first generation offspring, are immediate research needs. Future research should also address the appropriate scale at which to conduct and monitor scaled quail translocations. We intensively monitored 11,500 ha and aerially-searched approximately 125,000 additional ha, but were unable to locate all radio-collared hens throughout the monitoring period. This suggests that (a) our core study area may have been too small to effectively monitor survival and dispersal, and (b) more intensive monitoring may be necessary to keep up with dispersing scaled quail.

MANAGEMENT IMPLICATIONS

Based on the results of our study, it may be advantageous for future translocation efforts to use a soft-release technique and translocate a higher proportion of adults to maximize survival and minimize emigration off the release site.

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