Grant Report

California Quail

Translocation from Idaho to Texas

California Quail: Translocation from Idaho to Texas

Final Report

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BRIEF:

1 **Problem**: Quail and quail hunters, have declined 80% in Texas resulting in millions of dollars of lost revenue annually.

2 **Goal**: Determine the feasibility of translocating wild California valley quail from Idaho to Texas.

AgriLife Funding at Work

With the generous funding from Texas AgriLife Extension, we completed the first translocation of wild valley quail to Texas, and the first description of valley quail chick development.

3 **Results:** In just 2 years, we successfully translocated **748** wild California valley quail from Idaho to Texas. We documented **11** unique predator species, determined preferred roost sites in Texas, recorded **>25,000** quail locations, observed juveniles, and recorded carryover. We also determined the best ration for quail translocations and conducted the first anti-predator behavior study, the first descriptive developmental study, and the first analysis of heat stress on developing California valley quail.

4 **Broader Impacts:** In just 2 years, funding provided **8** MS graduate assistantships, **1** postdoctoral fellowship, **15** scientific presentations and published abstracts, **3** first place and **1** third place presentation award, **2** faculty awards, **7** popular media articles, and **6** journal articles in progress.

5 **Future Directions:** Determine the feasibility of establishing a sustainable population of California valley quail in Texas. This will entail discovering ways to increase survival and nest success, mitigate heat, reduce stress during translocations, and increase translocation numbers.

Submitted to:
Chancellor John Sharp
Dr. Jeff Hyde
Dr. Roel Lopez

Submitted by:
Dr. Kelly Reyna
Primary Investigator, The Quail Research Laboratory
Assistant Professor and Director
Texas A&M University Commerce

"Texas quail and quail hunters have declined 80% over the last 50 years, resulting in millions of dollars of lost revenue per year. Introducing wild valley quail to Texas is a novel solution."

INTRODUCTION

One of the biggest wildlife conservation challenges in Texas is the declining numbers of quail and quail hunters (Sauer et al. 2017, Haughey 2018, Purvis 2018). In northeast Texas, bobwhite quail populations (*Colinus virginianus*) and quail hunters have become largely undetectable and recreationally extinct. Because quail hunters fund a large portion of quail conservation, the disappearance of quail and quail hunters is not only alarming for the sustainability of quail hunting; it has also resulted in the loss of millions of dollars of quail conservation funding. Quail hunting in Texas generates >$69 million in retail sales, >$5 million in federal income taxes, and has created >1,200 jobs (LaBarbera 2002). Additionally, revenues generated from upland game bird leases (per acre) eclipse that of all other agricultural products (Woods 2013). Quail hunting is a valued contributor to the state's economy that is in jeopardy with declining bobwhites. Translocating California valley quail to Texas could help revive Texas quail hunting, quail hunters, and associated funding.

The major cause of the native bobwhite quail decline is habitat loss, due mostly to the conversion of quail habitat to rangeland grasses not beneficial to quail (e.g., Coastal Bermuda) and overgrazing by livestock. For remedy, many northeast Texas landowners have actively restored quail habitat, anticipating the quail's return (Martin et al. 2017) and hoping to reap the financial rewards of quail hunting (Johnson et al. 2012). Because there are no detectable wild populations in the Northeast Texas, there is an increasing interest in restoring quail with tools such as translocations (Martin et al. 2017).

Since at least the 1800's, hundreds of thousands of wild bobwhites have been translocated to Texas, mainly when source populations thrived in Mexico (Whitt et al. 2017). Now, with bobwhites on a steep decline (down 80% since 1967) translocations of bobwhites in Texas are extremely rare and only carried out for research purposes. However, **California valley quail (*Callipepla californica*) is one quail species native to the U.S. that is increasing in population numbers** and has been translocated successfully to many states and countries (Phillips 1928, , Leopold 1977, Zornes and Bishop 2009, Sauer et al. 2017). Valley quail are hardy birds that have demonstrated an extraordinary adaptability to novel habitats (Blair 1996) and have thrived as bobwhites have perished.

One successful translocation of valley quail is their introduction to Idaho in the 1880's (Edminster 1954). Started with just a few hundred birds from California, valley quail have thrived in Idaho despite changing agricultural practices (Sauer et al. 2017), and typically generate 1.3 million days of outdoor recreation and $135 million in economic activity per year (UGBSAC 2010).

Research Goals

The **overarching goal** of this research was to determine the feasibility of translocating wild California valley quail from Idaho to Texas. To accomplish this goal, we set the following objectives: **1**) translocate wild valley quail to Texas, **2**) evaluate the impact of predators on translocated quail, **3**) record the behavioral response of valley quail to predators, **4**) determine the impacts of Texas heat on the development of valley quail, **5**) establish the developmental differences between bobwhite and valley quail, **6**) discover factors that improve the success of quail translocations, and **7**) assess the feasibility of establishing a sustainable valley quail population.

Predator Impacts on Translocated Quail

Predation has a major impact on bird survival and translocation success (Martin et al. 2017), and is responsible for up to 89% of nest failures and 93% of adult mortalities (DeVos and Mueller 1993, Palmer et al. 2019). Meso-mammals such as raccoons (*Procyon lotor*), armadillos (*Dasypus novemcinctus*), and opossums (*Didelphis virginianus*) are primary mammalian predators affecting bobwhites and scaled quail in Texas (*Callipepla squamata*; Rollins and Carroll 2001). Primary avian predators in Texas are Cooper's hawks (*Accipiter cooperii*), sharp-shinned hawks (*Accipiter striatus*), red-tailed hawks (*Buteo jamaicensis*), and northern harriers (*Circus hudsonius*; Stoddard 1931, Rollins and Carroll 2001). This study evaluated the presence and relative abundance of predators and their potential impact on translocated valley quail.

Predator Avoidance Behavior of Translocated Quail

The primary cause of mortality during quail population restorations, e.g., translocations or releases of captive-reared birds, is predation (Roseberry et al. 1987, DeVos and Speake 1995, Woolstenuhulme 2001, Carter 2015, Martin et al. 2017). Curtis et al. (1988) determined that 60.7% and 64.4% of native bobwhite deaths annually were caused by avian predators, with 30.4% and 35.6% attributed to mammalian predators. However, when quail (wild or captive-reared) were introduced to a new area, mortality significantly increased, with wild translocated birds surviving longer than released captive-reared birds (Dickens et al. 2009, Dickens et al. 2010, Roseberry et al. 1987, Perez et al. 2002).

The main deterrent to quail population restorations techniques is that they are cost prohibitive for the typical Texas landowner (Kock et al. 2010, Weise et al. 2014). Translocations are very expensive, costing as much as $300 per bird, and releasing captive-reared birds, while cheaper per bird, is historically ineffective, thus not worth the money.

Reyna and Newman (2018) posited that releasing captive-reared quail would be a more pragmatic and cost-effective solution to quail population restoration than translocations ***if*** captive-reared quail had the same rate of survival as translocated or resident wild quail. In an experiment to determine the difference in survival, they exposed wild translocated and captive-reared northern bobwhites to simulated aerial and terrestrial predator attacks. They demonstrated that captive-reared birds identified predators more quickly and reacted faster than wild-trapped birds. Wild quail held or walked away in response to predators compared to the almost immediate flush of the captive-reared quail, suggesting the holding behavior in captive-reared bobwhite quail is absent. Based on these results, they hypothesized that wild translocated quail held longer for the advantage of staying concealed while conserving energy and captive-reared birds perished quicker because they flushed and revealed their position to predators.

This study, while still in progress, sought to determine if the predator response behavior observed in bobwhites is present in valley quail. The main objectives of this study were to simulate aerial and terrestrial predator attacks on both translocated and captive-reared valley quail and determine: 1) time to threat detection, 2) time to anti-predator defense, and 3) type of anti-predator defense. The results of this study could help improve survival probabilities for attempting population restoration with captive-reared valley quail.

Impacts of Texas Heat on Valley Quail Development

All North American quail species experience variability in population size and production during drought years and in arid regions (Miller 1950, Wallmo and Uzell 1958, McMillan 1964, Wauer 1973, Heffelfinger et al. 1999, Hernández et al. 2005), including valley quail (Zornes and Bishop 2009). However, the complex relationship between quail populations and drought needs further study.

Texas is known to experience extreme droughts affecting the production of native quail (Guthery, et al. 2001, Reyna et al. 2012, Reyna and Burggren 2017, Reyna 2019). High temperatures experienced during drought are especially detrimental to bobwhite embryos during the pre-incubation period, when they are exposed to the environment without the thermal buffer of an incubating parent. Reyna and Burggren (2012) showed that although bobwhite embryos have a high thermal tolerance, exposure to 42° C (107° F) for 3 h significantly decreased hatchability. Further, when bobwhite eggs were exposed to simulated drought temperatures in a laboratory, hatchlings exhibited developmental deformities, reduced mass, disrupted hatching synchrony, and higher mortality (Reyna and Burggren 2017, Reyna 2019). These studies suggest that heat stress during the pre-incubation period could limit production of northern bobwhites during drought years. However, it is not known whether valley quail eggs are similarly affected.

As part of the valley quail translocation project, our objective was to determine if high temperatures experienced during drought in Texas negatively impact valley quail development, hatching, and survival. The results will shed light on the difference in drought tolerance between bobwhites and valley quail and should explain production results of this study as they pertain to heat stress and drought.

Developmental Trajectory of California Valley Quail

In order to adequately assess the impact of stressors on valley quail during pre-incubation or incubation, a thorough understanding of embryonic development is needed. While detailed studies exist for the chicken (*Gallus gallus domesticus*; Hamburger and Hamilton 1951), Japanese quail (*Coturnix coturnix*; Padgett and Ivey 1960), and northern bobwhites (*Hendrickx and Hanzlik* 1965) the literature is lacking a detailed chart of embryological development for the valley quail. Here, we documented California valley quail development using many of the same developmental milestones described in Hamburger and Hamilton (1951).

Translocation Weight Loss

Translocations of North American quail species over long distances (>1,000 km) have been conducted since ~1750 (Gosse and Hill 1851), when northern bobwhites were translocated to Jamaica. Translocations of northern bobwhites to Washington, Oregon, and Idaho in the 1860s and 1870s have successfully established self-sustaining populations (Phillips 1928). While comments by Beebe (1888) demonstrate concern regarding shipping conditions of quail >130 years ago, largely no data exists regarding quail weight loss during translocation.

The most thoroughly covered equivalent is the measurement of weight loss in broiler hens during the interval between harvest and slaughter, which is typically 0.3–0.6% per h for the first 3 h and 0.18–0.42% per h, subsequently (Bilgili 2002). However, such estimates are rarely made for periods longer than 12–16 h (Carlson et al. 1975, Fletcher and Rahn 1982, Northcutt et al. 2003).

The translocations of this study required a ~48-h shipping period, where birds were shipped in individual cells within a larger shipping box. Including water in the box was impractical because it could have damaged the box, affected the body temperature of the quail, and potentially fostered mold growth. However, shipping birds with a source of preformed water (e.g., cucumbers) attached to the shipping container could reduce the amount of weight loss due to dehydration and lack of food. Thus, the objectives of this study were to examine shipping weight loss in translocated valley quail and estimate the amount of travel ration needed during a 48-h shipping period. Applying the results of this study to future translocations may help reduce stress and increase survival probability.

PROJECT DESIGN

The **overarching goal** of the project was to determine the feasibility of translocating wild California quail from Idaho to Texas. To accomplish this objective, we trapped, transported, released, and monitored valley quail and accomplished additional experimental elements necessary to evaluate the project (**Figure 1**).

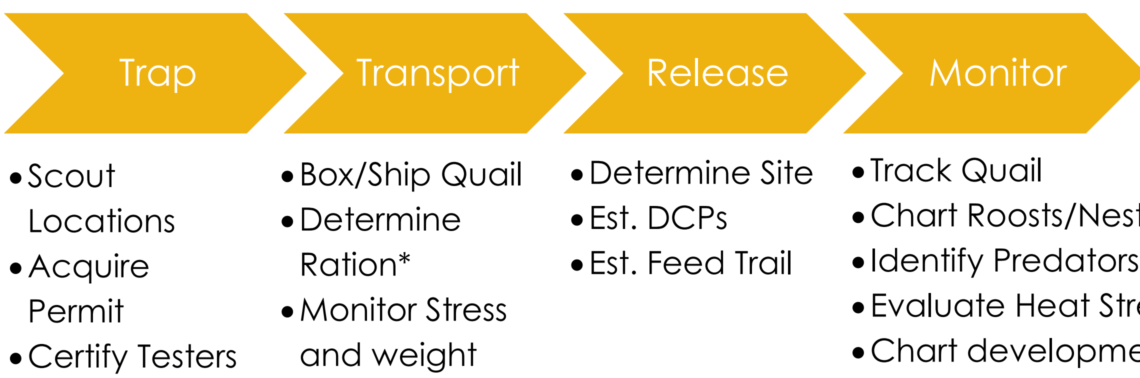

Figure 1. Elements of the valley quail translocation experiment. * Indicates lab setting.

MATERIAL AND METHODS

Study Sites

Wild California valley quail were trapped in Ada and Canyon Counties of Idaho, in the Treasure Valley portion of the Snake River Plain Ecoregion. Much of the Treasure valley consists of floodplain and rolling hills between and along the Snake and Boise Rivers. The region is mostly cropland, increasingly being replaced by suburban development (McGrath et al. 2002). Mean monthly low temperatures for Boise, the Ada county seat, range from -4.1° C (24.7° F) in January to 15.8° C (60.4° F) in August. Mean monthly high temperatures range from 3.2° C (37.8° F) in January to 32.9° C (91.2° F) in August. Mean annual precipitation in Boise is 29.8 cm (11.7 in) with 19.8 cm (7.80 in) of the total falling November–May (Arguez et al. 2011).

The release site was located in Fannin County, TX on ~485 ha (1,200 acres) of private land managed for wildlife (**Figure 2**). The site was located in the northern Post Oak Savanna ecoregion of Texas (Griffith et al. 2004). The vegetation was a mosaic of native grasslands, beneficial brush, forb species, and forested regions (**Figure 3**). The site was selected for its high quality quail habitat. The climate in Fannin County is characterized by hot summers and cool winters. Mean monthly low temperatures in Bonham, the county seat, range from -0.6° C (30.9° F) in January to 21.6° C (70.8° F) in August. Mean monthly high temperatures range from 5.4° C (41.7° F) in January to 41.1° C (93.3° F) in August. Mean annual precipitation is 117.1 cm (46.1 in), where May, June, and October are the wettest months (Arguez et al. 2011).

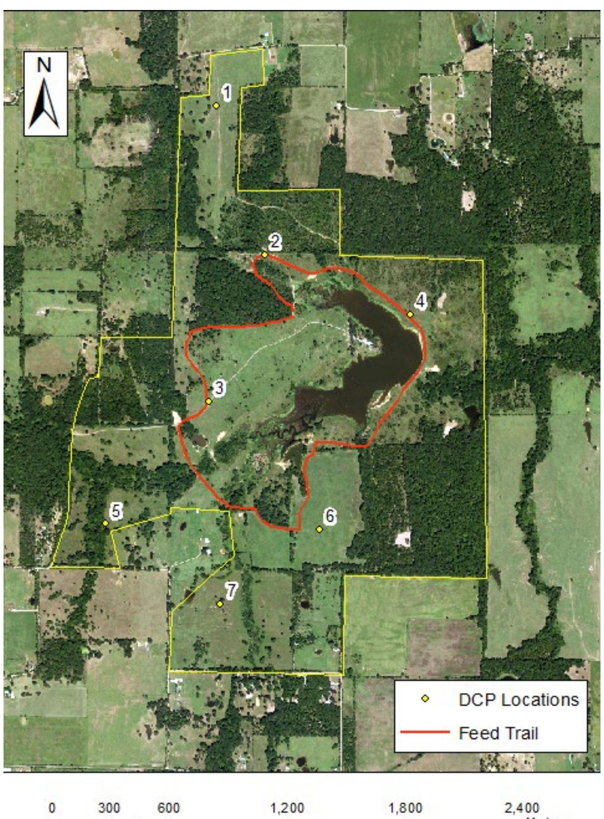

Figure 2. Study site for California quail translocations 2019–2020. Numbers indicate data collection points. Red line shows the path of the feed trail.

Site Preparation

We established 7 Data Collection Points (DCPs; **Figure 2**) ≥ 800 m apart (Whitt 2019). Since providing supplemental feed can reduce mortality by decreasing foraging time (Sisson et al. 2000), a ~5.8 km (3.6 mi) feed trail was established and replenished every 2 wks. The feed consisted of ~226 kg (500 lbs.) of hen scratch, a mixture of cracked corn (*Zea mays*), milo (*Sorghum bicolor*), and wheat (*Triticum aestivum*). Feed was hand-spread near the release site and broadcasted on the feed trail using a 12-v game feeder (55-gal Classic Game Feeder, One and Done Pro, Garland, TX) placed in the back of a UTV (Ranger Crew 570-4, Polaris, Medina, MN). For an additional food source, the landowner had a gravity feeder near the center of the study site (Quail feeder, 1,000 lb., Outback Wildlife Feeders, Gilmer, TX). However, in March 2020, predators were frequently stationed at or near the feeder, thus it was inactivated in April.

Figure 3. Quail habitat of the release site of translocated California quail, in Fannin County, TX, 2019–2020.

Quail Trapping

An initial survey of the trapping sites was conducted by Dr. Kelly Reyna and Dr. Jeff Whitt of TAMUC, in coordination with the Idaho Department of Fish and Game (IDFG) and area landowners. We determined that the best trapping area would be in the "quail nuisance area," where a farmer had observed a large quantity of quail eating his crops.

Quail were trapped using modified funnel traps (Stoddard 1931, Smith and Stormer 1981) under IDFG permit 181220. Following each trapping session, we recorded age, gender, mass, and the length of each quail's tarsus, beak, and wing chord. All trapped quail were affixed with a numbered aluminum leg band (Size 8, National Band & Tag Co, Newport, KY, USA). Blood samples (≤100 µL) were extracted from the brachial vein of each bird (Owen 2011) using a lancet and a 100 µL heparinized micro-hematocrit capillary tube (51608, Pulmolab, Northridge, CA) for disease testing and future genetic analysis.

For disease testing, all project personnel were certified to test birds for Pullorum disease and Fowl typhoid (PT) at Texas A&M University Veterinary Medical Diagnostic Laboratory. PT antigen (Charles River Laboratories, Wilmington, MA, USA) was combined with ~20 µL of blood on site for a rapid whole-blood plate test. Additionally, 10 blood samples per flock were tested for avian influenza at an off-site laboratory (Animal Health Laboratories, Boise, ID). Remaining blood samples were transferred to Whatman FTA blotter cards (Sigma Aldritch, St. Louis, MO) for future genetic analyses (Smith and Burgoyne 2004). Once all disease tests were certified negative, we obtained a permit from Texas Animal Health Commission to ship birds to Texas.

Following processing, the birds were placed in a custom-made, 3.7 x 2.4 x 2.4 m (12 x 8 x 8 ft), 3-room, outdoor holding aviary (Fannin Fabrication, Inc., Bonham, TX, USA) until shipment (**Figure 4**). Enrichments and refinements in the outdoor aviary allowed birds to roost and socialize. Birds were provided water and food *ad libitum* (hen scratch, millet sprays, cucumber slices, and Deluxe Dove and Quail Blend, Chuckanut All Natural Products, Jefferson, OR).

Quail Transport

Quail were shipped in boxes approved by the United States Postal Service for shipping birds (USPS; Single 16-Bird Shipping Box, Boxes for Birds, Conway, AR, USA). In 2019, a slice of cucumber was attached to each bird compartment using zip ties as a source of food and preformed water (L. Webster, Oklahoma Quail Ranch, personal communication). In 2020, based on the results of a laboratory experiment, we affixed millet sprays (~30–45 g) to each enclosure. The boxes were shipped USPS Priority Mail Express 1-day. However, due to flight schedules, the birds did not leave Boise until ~0600 the day after drop-off. Birds arrived in Commerce, TX ~0800 on the second day. Total shipping time from drop-off to receipt in Texas was 40–48 h. Due to the intermittent nature of trapping, birds were placed in 3 different shipments within 14 d in 2019, and 5 shipments within 16 d in 2020.

Upon arrival in Commerce, TX, shipping boxes were opened inside a screened enclosure for processing (3.7 x 2.4 x 2.1 m, Tailgaterz, Wenzel, Boulder, Colorado, USA). Birds were weighed to determine transportation weight loss and their age and gender were verified. In 2019, birds were fitted with VHF transmitters (Pip-Ag393, Lotek Wireless Inc.) before release. In 2020, birds were fitted with VHF collars (A1070, Advanced Tracking Systems, Isanti, MN) or a solar-powered digital ID VHF tag (LifeTag, Cellular Tracking Technologies, Rio Grande, NJ). Once processed, birds were placed in carriers (KUHL Poly Quail Coop, QC Supply, Schuyler, NE, USA) and transported ~73 km away to the release site, in the rear cargo area of a pickup.

Figure 4. Wild California quail in one room of a 3-room outdoor aviary, prior to shipment. Roosts and socialization provided enrichment. An outer tarp reduced wind exposure and visibility, which calmed the birds.

Quail Release

Quail were released at 3 different locations across the property that were near loafing cover, feed location, and roost sites. Quail transport boxes were carried by hand to the locations and placed near brushy cover. Each box was opened by hand and quail were free to exit at will (**Figure 5**).

Figure 5. Wild California valley quail released in Texas, March 2020.

Quail Monitoring

Translocated quail locations were obtained using a combination of triangulation, direct tracking, and observations (Millspaugh et al. 2012). Birds with VHF collars were located with a VHF receiver (Biotracker 8, Lotek Wireless Inc.) once every 48 h for the first 30 d in 2019 and ≥2 times weekly thereafter. In 2020, birds with VHF transmitters were located ≥5 times per wk. The digital tags sent a unique digital ID approximately every 2 sec in full sun, and 30–200 times per h in the shade. ID signals were relayed by nodes to a sensor station that recorded tag ID, node ID, Universal time, and relative signal strength. These data were stored in the sensor station for later download. Tag location was estimated hourly by combining all signals received and weighting them towards the node(s) that received the most signals within that hour. If a VHF transmitter did not move for ≥3 consecutive tracking sessions (~1 wk), an attempt was made to flush the bird to determine its status. Recovered VHF transmitters and transmitters that were irretrievable yet not lost were classified as a mortality. Transmitter recovery dates and locations were recorded with a hand-held GPS (GPSMap 64st, Garmin, Olathe, KS). Survival was analyzed using the Kaplan-Meier (1958) procedure. Dispersal was calculated using Euclidian distance between release site and recovery or mortality site.

California quail roost in trees or elevated positions at night (Sumner 1935, Leopold 1977) unlike northern bobwhites. Little research has been done regarding California quail roosts, but roosts selection is partially due to predator avoidance (Weatherhead 1983), and roosting in trees could decrease valley quail predation rates at night. For this project, roost locations were determined using VHF telemetry and a hand-held thermal infrared viewer (Scout III, FLIR, Wilsonville, OR). Information on roost location preferences should inform habitat management decisions for future valley quail translocations.

Predator Survey

Relative abundance of predator species on the study area was assessed using predator scent-stations (Sargeant et al. 1998). We placed fatty acid scent tablets (Predator Survey Disks, Wildlife Control supplies, East Granby, CT) enclosed in a wire frame cube ~2 m in front of a motion-triggered camera (119874C, Bushnell Corporation, Overland Park, KS) at each of the 7 DCPs. Stations were left active for 5 d and tablets were replaced after rainfall. We recorded visitation per scent-station night (SSN) as the number of scent stations x nights each was operational.

Aerial surveys were conducted twice per month in February, April, and May 2020 to examine relative abundance of aerial predators on the study site (Eakle et al. 1996). Surveys were conducted when wind speed was <3 m/s and no precipitation was present (Craig 1978). Two research personnel followed a ~5.8 km (3.6 mile) transect along the feed trail and recorded aerial predator species, time, date, weather conditions, and location. Incidental observations were also recorded.

To quantify nest predators, we established simulated nests on 4 transects of 6 nests each in 2019, and 5 transects of 6 nests each in 2020 (Major and Kendal 1996). Simulated nests were constructed within clumps of bunch grass (e.g., little bluestem; *Schizachyrium scoparium*) >0.5 m (1.6 ft) in diameter with 14

Coturnix quail eggs (*Coturnix japonica*) placed in the bottom of the nest to simulate valley quail nests (**Figure 6**). Coturnix eggs were readily available at local markets and are visually similar to valley quail eggs. Motion-triggered cameras were placed ≤2 m (6.6 ft) from the entry point of each nest. Nests were checked every 2–5 d. Eggs were replaced at 14 d to avoid attracting predators (Major and Kendal 1996). Nests were removed after 23 d. A nest was determined successful if no nest disturbance was observed at 23 d.

To capture daily predator presence, motion-triggered cameras were attached to t-posts placed in strategic locations on the study site near the feed trail, at the gravity feeder, and along game paths. Cameras were checked weekly to exchange memory cards and check batteries.

Figure 6. A quail research biologist records fate of simulated valley quail nests, May 2020.

Analysis of Predator Avoidance Behavior

To determine how valley quail respond behaviorally to predators, we simulated predator attacks and recorded the response time and type. Simulated predator attacks occurred in an outdoor experimental aviary (7 m x 4 m x 4 m) constructed of 38 mm (1.5") PVC pipe covered with a single layer of 2.5 cm (1 in) mesh netting (Heavy Knotted Poultry Netting, Pinnion Hatch Farms, Centralia, MO). The size of the flight pen restricted the quail to a central position for observation while still allowing them to initiate flight (Reyna and Newman 2018).

Prior to simulated predator attacks, quail were placed in the experimental aviary to acclimate to the new setting. To reduce acclimation time, ~200 g (7.1 oz) of feed was placed in the center of the aviary (a blend of white millet (*Panicum miliaceum*), safflower seed (*Carthamus tinctorius*), canola seed (*Brassica napus*), canary seed (*Phalaris canariensis*), wheat, and cracked corn; Deluxe Dove and Quail Blend, Chuckanut All Natural Products, Jefferson, OR). Quail were considered acclimated when normal feeding behavior and movement were displayed (Reyna and Newman 2018).

Once the quail were acclimated in the center of the aviary, the technician, who was concealed in a 4.3-m (14 ft) hide stand ~17 m (55 ft) from the aviary, initiated a simulated predator attack.

For the simulated mammalian predator attack, a remote-controlled car (Model 9125, Hosim, Shenzhen, China) was wrapped in faux fur to create a mammalian predator (**Figure 7**). Prior to the simulation, the mammalian predator was placed in a black hide box on one end of the experimental aviary (**Figure 8**). To mask the sound of the remote control car (an electric motor sound), a recording of the car was played on a repeating loop through a game call (Fusion, FoxPro, Inc., Lewistown, Pennsylvania, USA) to acclimatize the birds to the noise (Reyna and Newman 2018). We placed 4 remote cameras (Hero 7, GoPro, San Mateo, CA) on three adjacent sides and at the top of the aviary. To initiate the simulated mammalian attack, the technician drove the simulated mammal towards the acclimated birds (~4.2 m/s; 14.8 ft/s). Video recordings were used to determine 1) predator detection time, time in seconds from initiation of the simulated predator attack to threat detection, and 2) response time, time in seconds from threat detection to defense response. Behavioral responses were categorized as run, flush, or hold.

Figure 7. A simulated mammalian predator constructed by placing faux fur on a remote-controlled car.

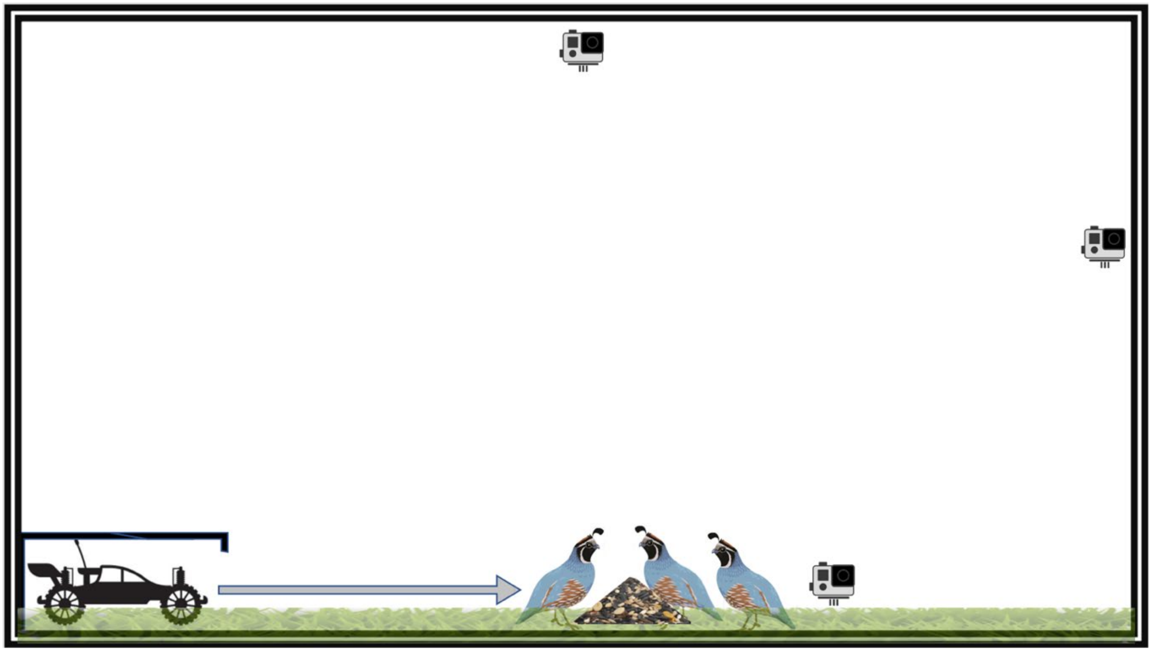

Figure 8. Experimental design of a simulated mammal attack on valley quail in an outdoor experimental aviary. A simulated mammal (fur covered RC car) was guided from a hide box towards acclimated quail. GoPro cameras recorded each simulation.

For the simulated aerial predator attack, a plywood cutout of a Cooper's hawk (77 cm x 43 cm; 30.3 x 9.4 in) was painted black to mimic a raptors' silhouette (**Figure 9**; Martin and Melvin 1964, Reyna and Newman 2018). Prior to the simulations, the wooden raptor was mounted to the top of the aviary at the center point with a monofilament fishing line so it would hang at quail height. The wooden raptor was drawn back into a black hide box at the top of one end of the aviary, and held in place by a removable cotter pin through the tail.

To initiate the simulated aerial predator attack, the hidden technician pulled the cotter pin with a rope from the hide stand, allowing the wooden raptor to swing in an arc over the birds in the center of the pen (**Figure 10**). Video recordings were used to determine 1) predator detection time, time in seconds from initiation of the simulated predator attack to threat detection, and 2) response time, time in seconds from threat detection to defense response. Behavioral responses were categorized as run, flush, or hold.

Figure 9. A simulated aerial predator constructed by cutting a silhouette of a Cooper's hawk (*Accipiter cooperii*) out of plywood.

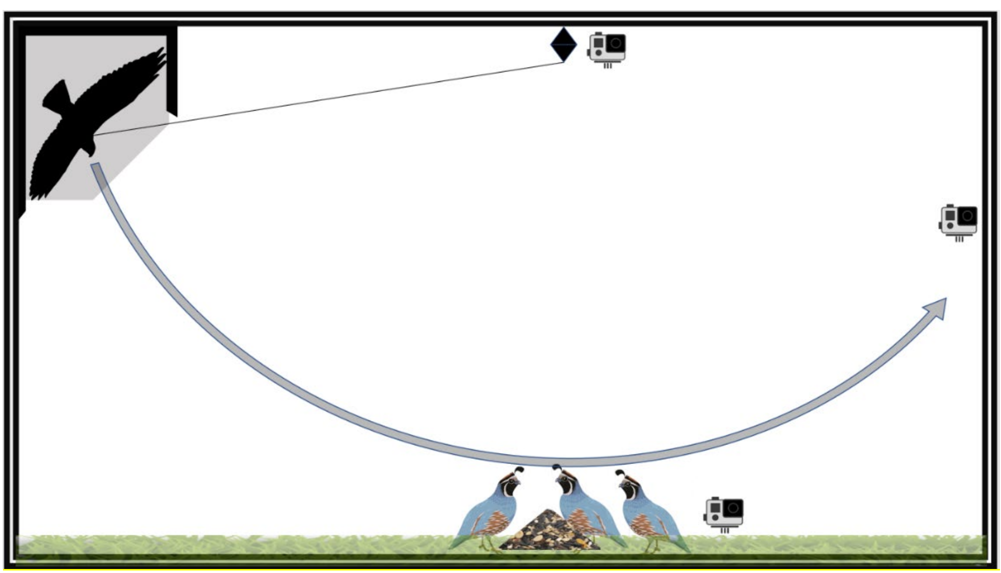

Figure 10. Experimental design of a simulated raptor attack on valley quail in an outdoor experimental aviary. A simulated raptor is released from hide box and swings towards acclimated quail. GoPro cameras recorded each simulation.

Thermal Stress Impacts

Fertilized California quail eggs were obtained from game bird farms with a record of date of collection (Stromberg's Chick and Game Birds Unlimited, Hackensack, MN; Murray McMurray Hatchery, Webster City, IA). Upon arrival, eggs were weighed and divided into 3 groups: drought (n = 180), non-drought (n = 180) and control (n = 90).

Each treatment group (drought and non-drought) was divided into 3 trials of 60 eggs. Eggs were placed on plastic egg trays blunt end up and labeled with an indelible marker (e.g., D-1-1 = Drought, Trial 1, Egg 1). Drought and non-drought eggs were subjected to a 12-d pre-incubation period of simulated natural conditions (**Table 1**). The peak temperature of each thermal treatment group was selected based on nesting studies showing temperatures peaked ≥40° C (102° F) in non-drought years and ≥45° C (115° F) in drought years (Reyna & Burggren 2017, Reyna & Burggren 2012, Guthery et al. 2005, Tomecek et al. 2017). Trial 1 eggs were placed directly into the pre-incubation environmental chamber (I-41LLVL, Percival Scientific, Perry, Iowa) and left unturned to simulate natural pre-incubation conditions (Reyna and Burggren 2017, Reyna 2019). Trials 2 and 3 were staggered by 3 d in order to isolate any pre-incubation chamber effects. After pre-incubation, all eggs were placed into the control incubator.

Table 1. Thermal regime for valley quail eggs during a 12-d pre-incubation period. Relative humidity was maintained at 60%.

	Thermal Treatment (°C)	
Time	Drought	Non-drought
00:00–07:59	30	25
08:00–10:59	35	30
11:00–13:59	40	35
14:00–16:59	45	40
17:00–23:59	30	25

Control group eggs were further divided into 3 groups (n = 30 eggs/group), and received no pre-incubation treatments. Eggs were placed blunt end up on plastic egg trays and labeled with an indelible marker (e.g., C-1-1 = Control, Trial 1, Egg 1). Trial 1 eggs were placed directly into the incubation chamber (37.8 °C; 100.0° F. 60% RH). Trials 2 and 3 were each staggered by 3 d in order to isolate any incubation thermal chamber effects. During incubation, eggs were turned every 1 h for the first 19 d. On d 20, eggs were placed in the hatching chamber of the control incubator until external pipping occurred.

To assess survival, non-viable eggs were removed on incubation d 20. Eggs unhatched after 23 d were candled to determine further action. If there was no internal pipping or embryo movement, eggs were removed, death was determined, and time to mortality was estimated based on developmental stage at the time of death (Hamburger and Hamilton 1951; Hendrix and Hanzlik 1965).

To determine water loss, egg mass was recorded with a digital scale (Scout SPX, Ohaus, Parsippany, NJ) 5 times; upon arrival, before placement into pre-incubation, on pre-incubation d 13, on incubation d 20, and immediately after external pipping.

On pre-incubation d 13, 30 eggs from each trial were randomly selected to determine embryonic development during pre-incubation. If present, embryos were extracted and weighed to the nearest 0.01 g. Embryos were aged and staged according to morphological indicators of development (Hamburger and Hamilton 1951; Hendrix and Hanzlik 1965).

When eggs become externally pipped, embryos were euthanized (Clifford 1984) and separated from the residual yolk. Embryos were weighed and length of the bill and tarsometatarsus were measured with a digital caliper to the nearest 10 μm (Sutherland 2004). Wing chord and length of the central digit, measured at a right angle from the distal end of the tarsometatarsus to the tip of the central digit (excluding the claw), were be measured with a flat ruler to the nearest 100 μm (Sutherland 2004).

To assess hatch, eggs were candled and visually observed daily. We recorded time to internal and external pipping, egg mass, incubation duration, and percentage of eggs hatched.

Embryonic Development

To assess embryonic development, 290 California quail eggs were acquired from Murray McMurray Hatchery (Webster City, IA). Eggs were weighed and labeled with an indelible marker, then incubated at 37.8° C (100.0° F) with 60% relative humidity. Eggs were weighed, measured, and photographed every 3 d until d 12. Randomly selected eggs were floated, candled, and opened to assess development.

Flotation measurements included recording height and width of eggs and floating each egg in three different 500 ml (16.9 oz) water baths with room temperature tap water, 37.8° C (100.0° F) tap water, and 37.8° C (100.0° F) purified water. The angle and position in which the egg floated was recorded.

Candled eggs were recorded by illuminating the egg from the underside and photographing the egg with a SLR camera (D3600, Nikon, Shinagawa, Tokyo, Japan). Candling was conducted in a portable photo booth with light-cancelling curtains. The egg was placed upside down on a black rubber stage to ensure the egg stayed in place without causing any damage, while photographing. Image-editing software was subsequently used to rotate the image into the upright position and adjust contrast to enhance detail (Photoshop 19.1.4, Adobe, Inc., Mountain View, CA, USA).

After floating and candling, randomly selected eggs were injected with methylene blue dye, opened and photographed with a camera mounted on a microscope (M80/IC90E, Leica Camera, AG, Wetzlar, Germany). The stage was recorded by comparing the embryonic developmental characteristics to results of 3 developmental studies on chickens, bobwhite quail, and coturnix quail, respectively (Hamburger and Hamilton 1951, Hendrikx and Hanzlik 1965, Ainsworth et al. 2010). Measurements recorded from the opened eggs included blastoderm, total body length, appendage development, bill length, wing, tarsus and third toe length.

Translocation Weight Loss

Mass for wild valley quail was recorded after trapping and after shipping (immediately prior to release) to determine translocation weight loss. Initial laboratory experiments to determine factors that cause translocation weight loss in quail were carried out with northern bobwhites due to limited captive-reared quail availability, due to COVID-19.

Upon arrival, birds were given a visual health assessment with weight, gender, and age recorded. Each bird was assigned an ID and randomly sorted into 2 groups based on an experimental feeding regime. Quail were then placed within individual cells of research-approved breeding pens (Quail Battery Breeding Pen, GQF Manufacturing Company, Savannah, GA) located in a temperature and light-controlled room of the animal care facility at Texas A&M University-Commerce. Each cell (25 cm x 61 cm; 9.8 x 24.0 in) within the pen was designed to hold 4 birds. To ensure free movement, equal access to food, reduced stress, and simulation of shipment, we placed 1 bird in each cell.

To initiate the translocation weight loss experiment, birds in group 1(control) were fed a game bird grain mix and given water *ad libitum* from small troughs attached to the pens. Birds in groups 2 (supplemental feed) were given an experimental diet as follows: Trial 1, ¼ cucumber or whole cucumber; Trial 2; seed patty or millet spray. In order to simulate translocation from Idaho to Texas, each trial lasted 48 h. Subsequently, the quail and any remaining food were weighed. An ANOVA was used to compare weight loss between groups. The results of this study informed our 2020 translocation.

RESULTS

The first translocations of wild California quail to Texas occurred with 248 wild valley quail moved in 2019 and 500 wild valley quail moved in 2020. For tracking purposes, a VHF radio transmitter was placed on 108 birds in 2019 and 50 birds in 2020. Additionally, a solar-powered digital ID cellular tag was placed on 93 birds in 2020. In 2019, we recorded ~300 bird locations from the VHF tags. In 2020, we recorded 144 bird locations from VHF tags, and >25,000 bird locations from digital tags. All necessary permits and protocols were acquired successfully. No birds tested positive for any disease.

Survival

Due to the short battery life and failures of VHF tags, survival was estimated at 6 wks post release. Survival of birds with tracking devices was 63% (VHF) in 2019, and 38.8% (VHF) and 92.5% (digital tag) in 2020 (**Figure 11**). Survival rate was greater for birds with VHF transmitters compared to digital tags (log-rank test, df = 1, $\chi 2 = 9.71$, $0.001 < P < 0.01$). The 4 longest-lived birds with tracking devices (74, 75, 102, and 118 d) all had digital tags. Only 37% of birds had tracking devices in 2019, and 29% of birds had tracking devices in 2020. No birds with tracking devices are currently locatable.

Among birds without tacking devices, survival rate is less certain. At 60 d following the 2019 release, we estimated population of surviving birds without transmitters at ~30, based on observations and assembly calls. At 120 d after our first release, only 5-6 birds were regularly observed on the site. However, on 21 August 2019, a separate covey of ~15 birds was flushed and appeared to include at least 2 juveniles, indicating ≥1 successful nesting event by the translocated birds. While none of the 2019 birds with a transmitter was known to survive, more birds were seen in fall, with ≥20 California quail, including ≥2 juveniles still present and alive on the site ~6 months after release, with an unknown number outside the study area.

Interestingly, one known bird is still alive from the 2019 release; bird 681 was found 30.5 km (18 miles) away in Bells, Texas in a chicken coop. At the time of this report, at least 1 covey of birds from the 2020 translocation still resides near the release site. It is unknown how many reside off-site.

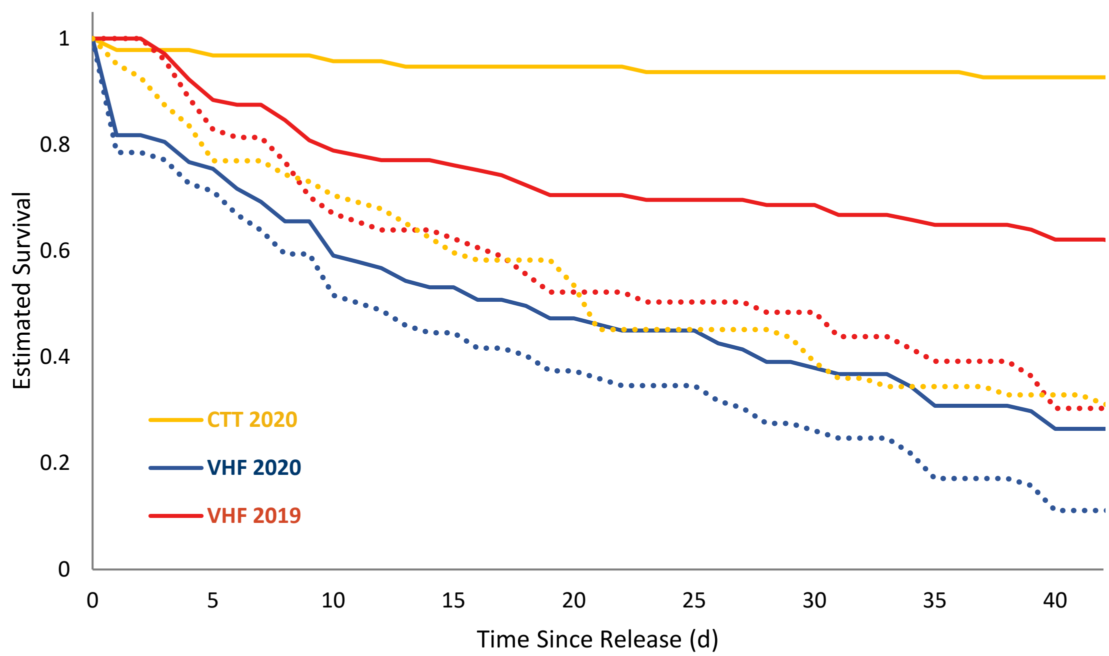

Figure 11. Estimated survival for translocated valley quail with VHF trackers in 2019 (red) and 2020 (blue), and CTT digital tags in 2020 (gold) based on recovered tags (top solid line) and Kaplan-Meier survival estimations (bottom dotted line), in which tags with an unknown location are censored.

Dispersal

Among birds with tracking devices, the median dispersal distance for birds with VHF transmitters was 633.5 m in 2019, 246.6 m in 2020, and 310.4 m for 2020 birds with digital tags. Mean dispersal distance for birds with VHF transmitters was 691.9 ± 70.0 m in 2019, 402.5 ± 59.6 m in 2020, and 383.4 ± 33.8 m for 2020 birds with digital tags. The maximum dispersal distance was 2.23 km (1.39 mi), the minimum 12.6 m (**Figure 12**). Dispersal in 2019 was greater than that for birds with VHF transmitters in 2020 (Mann-Whitney U, P = 0.0003) and for birds with digital tags (Mann-Whitney U, P = 0.000001). There was no difference in dispersal between the 2020 groups (Mann-Whitney U, P = 0.24). Of note, one bird in 2019, without a VHF transmitter, was found in 2020 within the city limits of Bells, TX, >30 km (18 mi) from the release site. With a dispersal distance >21 standard deviations from others in the same cohort and no tracking device, this individual was considered an outlier and not included in the dispersal analysis.

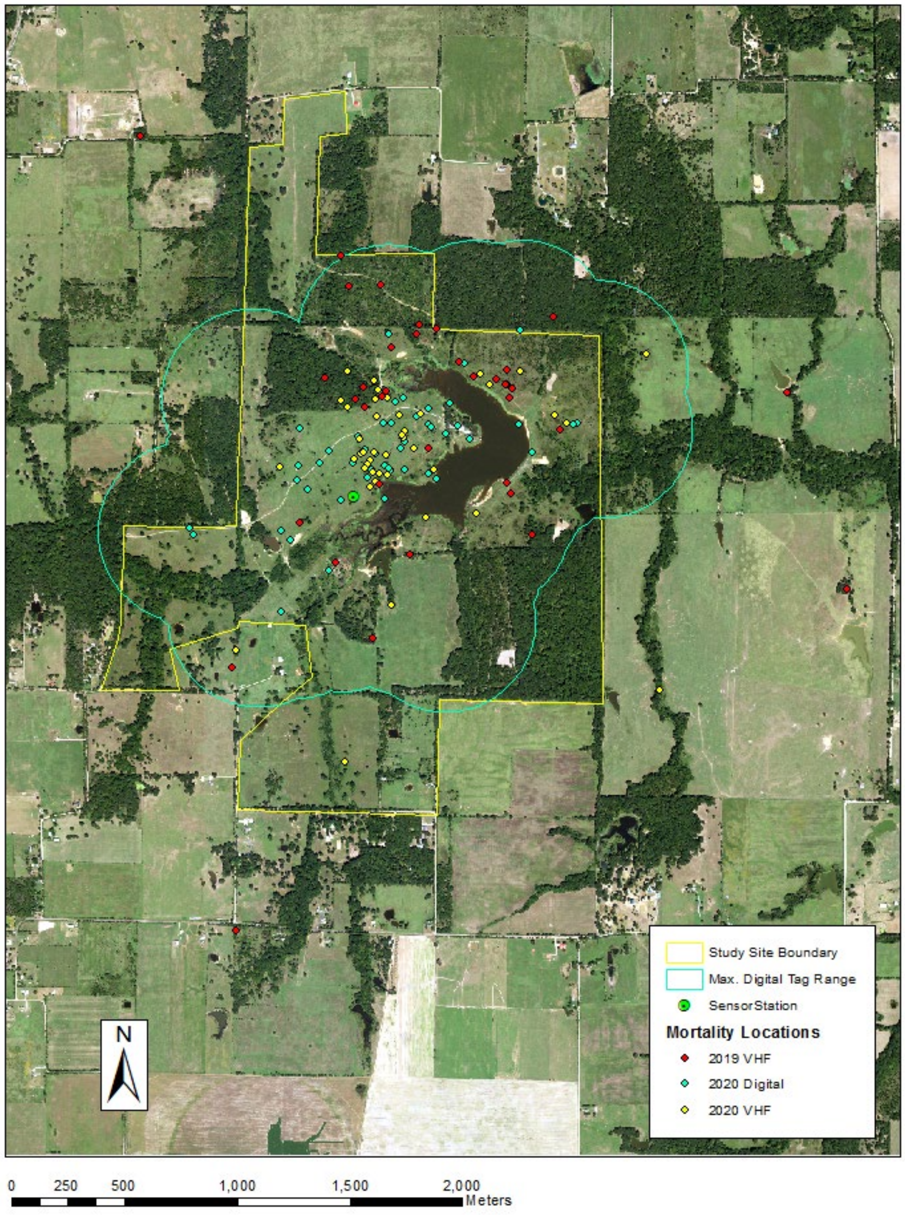

Figure 12. Locations of VHF transmitters recovered from translocated California quail mortalities in Fannin County, Texas in 2019 and 2020 along with estimated mortality locations for birds with digital tags.

Roost Preference

Of the 14 roost sites recorded in 2019, 9 consisted of multiple young trees that grew closely together, making dense cover for the birds. The trees had a mean diameter at breast height (DBH) of 9.0 ± 2.9 cm and mean height of 5.5 ± 1.6 m (**Figure 13**). The remaining roosts consisted of singular eastern red cedar (*Juniperus virginiana*) trees and ground roosts. The predominate roost type was oak (*Quercus sp.*) trees. All sites were <15 m from escape cover such as *Rubus sp*. and *Smilax sp*. Roost sites were located 166.1 ± 52.6 m from permanent water sources and 61.6 ± 29.2 m from maintained trails. Mean distance to the nearest release site was 161.8 ± 129.2 m. Only one instance was recorded of a roost site being used more than once.

We recorded 10 roost sites in 2020, with a height of 8 ± 1.5 m and diameter of 22.7 ± 7.6 cm. Sites were 171.6 ± 20.0 m from permanent water and 65.9 ± 17.0 m from maintained roads or trails. All roost sites were <15 m from escape cover, some were within cover. At least 2 roost sites were used multiple times.

Figure 13. A typical roost location for valley quail translocated to northeast Texas. An oak tree, ~5 m in height, surrounded by shorter trees and dense brush.

Predator Surveys

Scent stations cameras (n = 14) captured 7 mammalian and 1 avian predator of quail (**Figure 14**). The most common predator in 2019 was raccoon at 0.32 visits per SSN, accounting for 28.6% of total visits for both years combined. Feral hogs were the most common predator recorded in 2020, at 0.31 visits per SSN and accounting for 23.4% of total visits for both years combined. There was no difference in animal visits between 2019 and 2020 ($\chi 2 = 11.3$, df = 7, $0.10 < P < 0.20$). With the exception of bobcat and greater roadrunner (*Geococcyx californianus*), all predator species were seen both years.

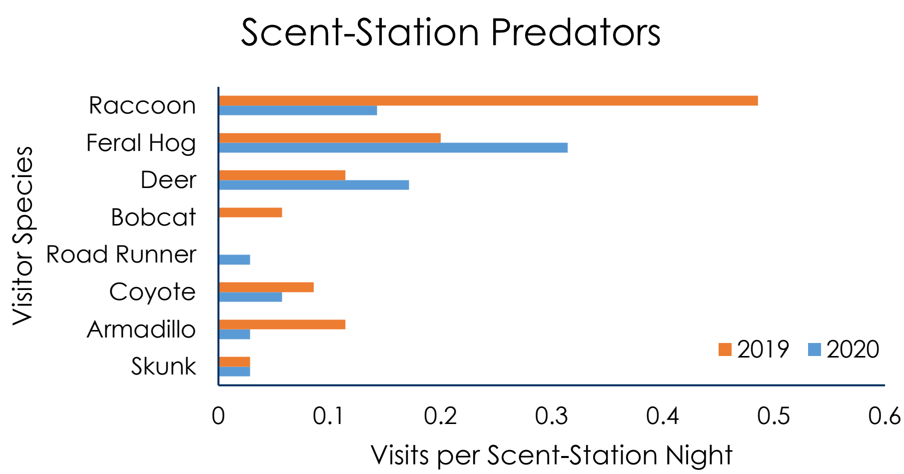

Figure 14. Predator visits per scent-stations night on a valley quail translocation site 27 April – 19 May 2019 and 8–20 June 2020.

Nine raptor species were recorded during raptor surveys February–June 2020 (with the exception of March due to COVID-19 restrictions). Incidental observations of 8 raptor species were also recorded. The red-tailed hawk (*Buteo jamaicensis*) was the most commonly observed raptor at 45.2% of individuals recorded during surveys and 37.5% of total observations. Red-shouldered hawks (*Buteo lineatus*) and northern harriers were recorded multiple times. Only 1 Cooper's hawk (Accipiter cooperii) was observed. While not recorded as raptors, 6 American crows (*Corvus brachyrhynchos*), known nest predators, were also seen during the February survey (**Figure 15**).

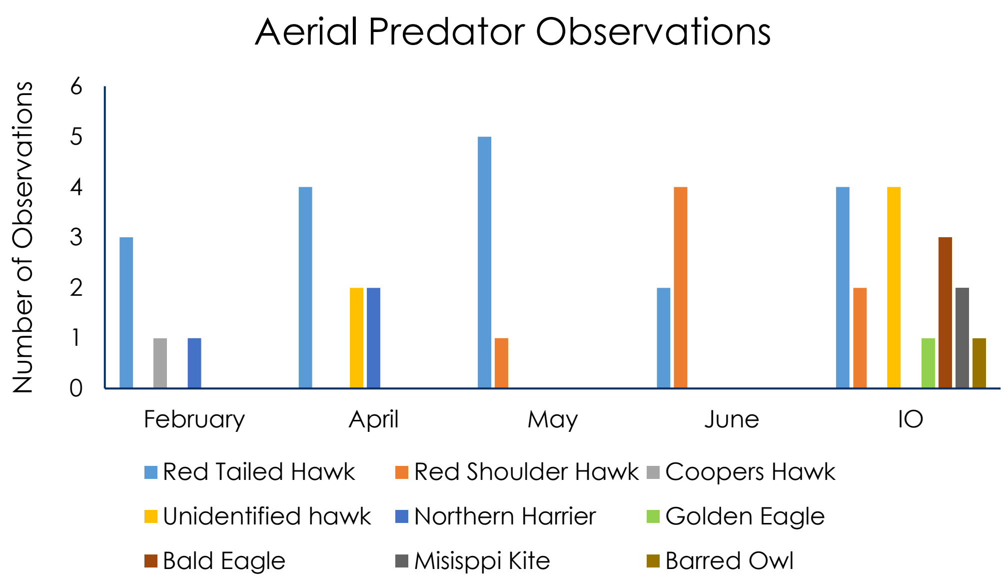

Figure 15. Numbers of aerial predators recorded in 2020 during each month's raptor survey and indirect observations (IO).

Simulated nests were evaluated for 23 d in June–July of 2019 and 2020. Mean survival time for simulated nests was 5.25 ± 4.7 d, in 2019, and 10.82 ± 1.58 d, in 2020. Only 1 nest (4%) survived for 23 d in 2019, 5 nests (20%) survived for 23 d in 2020. Nest survival was significantly greater in 2020 than in 2019 (**Figure 16**; $\chi 2 = 7.95$, df = 1, $0.002 < P < 0.005$). Interestingly, one nest had eggs broken or consumed by 3 animals: a raccoon, a rat snake (*Pantherophis* sp.), and a turkey vulture (*Cathartes aura*). In 2019, raccoons were the most common predator, depredating 16 (64.3%) of 25 nests (**Figure 17**). Skunks and armadillos each depredated 3 (10.7%) of 25 nests. In 2020, raccoons were the most common nest predator, depredating 9 (36%) of 25 nests; feral hogs depredated 3 (12%) of 25 nests (**Figure 18**). Overall, raccoons were responsible for 26, or 52% of nest predations. Nest predator frequency for 2019 was significantly different from that in 2020 ($\chi 2 = 19.2$, df = 9, $0.025 < P < 0.05$).

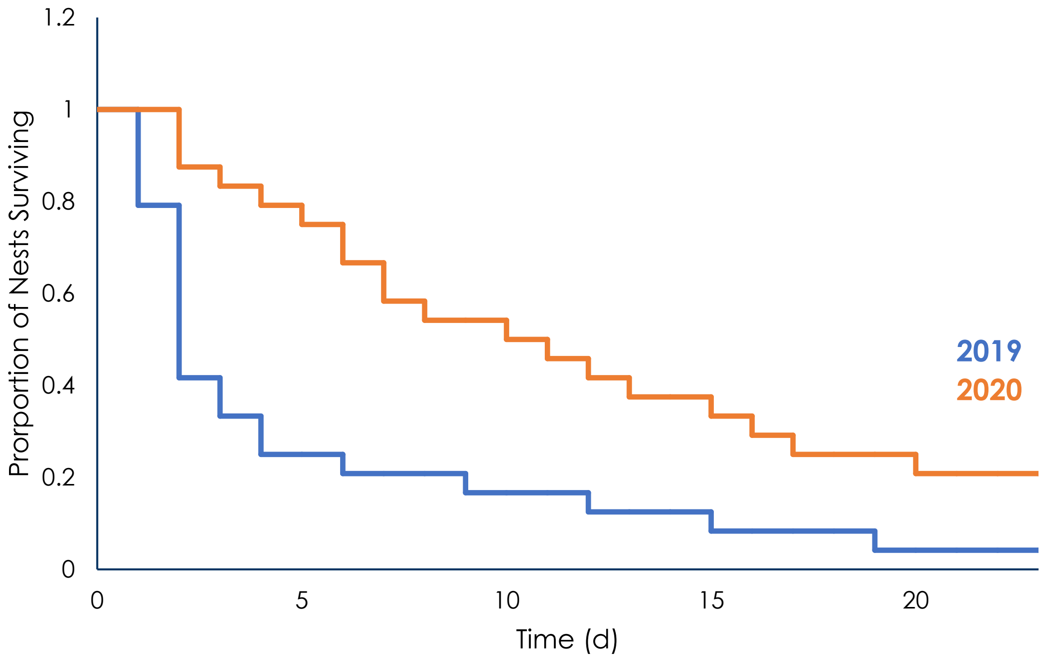

Figure 16. Kaplan-Meier (1958) survival curve for simulated valley quail nests in Fannin County, Texas, May–June 2019–2020.

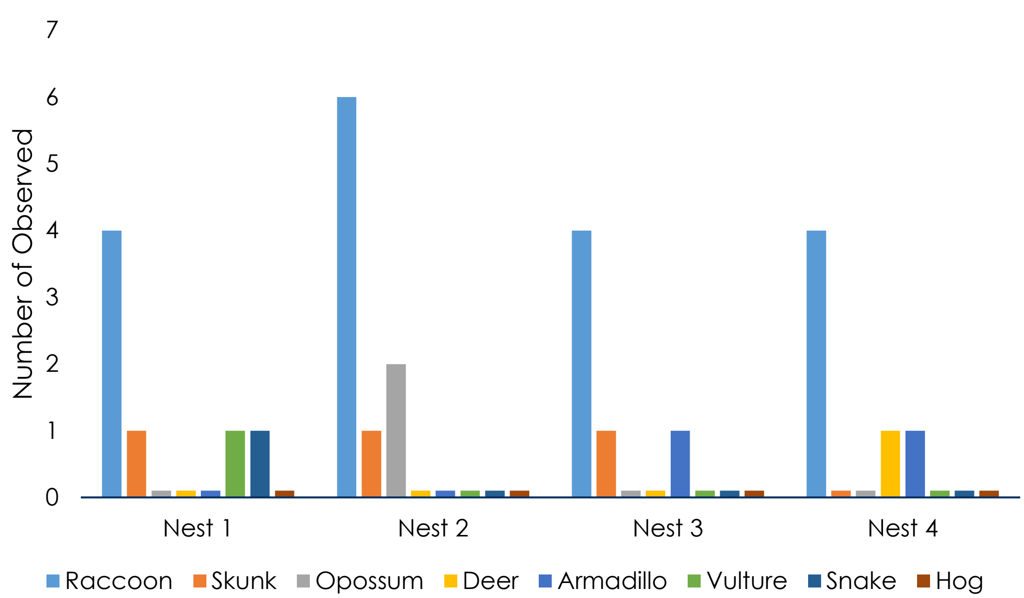

Figure 17. Nest predators by species for simulated California quail nests, May–June 2019.

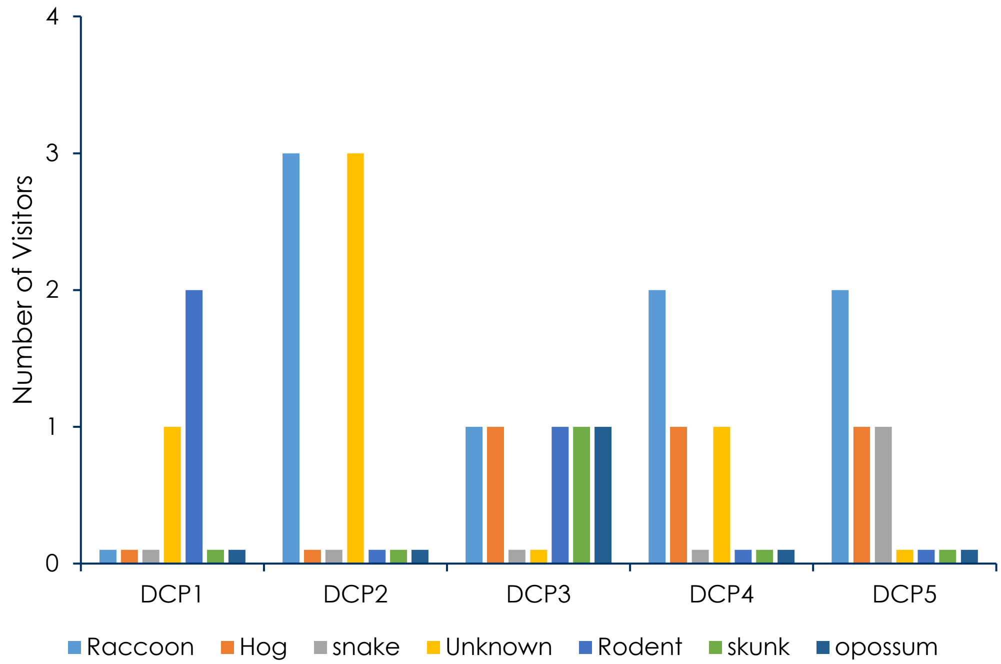

Figure 18. Nest predators by species for simulated California quail nests, May–June 2020.

Motion-activated cameras located in other regions of the study site produced ~170,000 digital images and videos, March 2019–May 2020. Images included 21 different avian, reptilian, or mammalian species, including 217 quail photos and 11 known predators of quail or their eggs. These include striped skunk (*Mephitis mephitis*), nine-banded armadillo (*Dasypus novemcinctus*), Virginia opossum (*Didelphis virginianus*), coyote (*Canis latrans*), bobcat (*Lynx rufus*), white-tailed deer (*Odocoileus virginianus*), raccoon (*Procyon lotor*), feral hogs (*Sus scrofa*), American crow (*Corvus brachyrhynchos*), turkey vulture (*Cathartes aura*), and rat snake (*Pantherophis sp.*). Eight species were photographed at the stationary gravity feeder in 2019, including a large bobcat (**Figures 19 and 20**).

Raccoons appeared in 31.4% of photographs, feral hogs (*Sus scrofa*) in 23.8%, and white-tailed deer in 19.3%. Because of their tendency to travel in sounders, feral hogs averaged 3.4 individuals per photograph taken, making them the most photographed species at 48% of all animals photographed. Raccoons accounted for 21.4% of animals photographed.

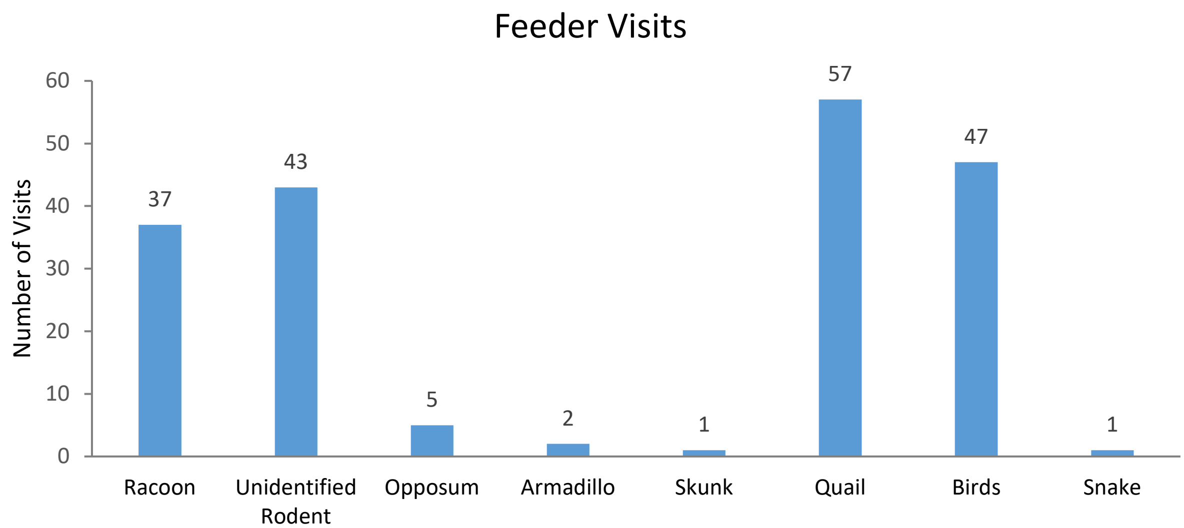

Figure 19. Number of visits by species to gravity feeder on valley quail translocation study site in Fannin County, Texas (2019–2020).

Figure 20. A male bobcat (Lynx rufus) at a gravity feeder on a valley quail translocation study site in 2019.

Analysis of Predator Avoidance Behavior

To date, 90 wild valley quail, tested after receipt but prior to release in Texas, have been analyzed in the predator avoidance behavior experiment. Since this project is still in progress, no captive-reared quail have been tested due to seasonal availability. Mean threat detection time was 0.24 ± 0.025 s. Mean response time was 0.53 ± 0.033 s. Both the threat detection time (0.20 ± 0.027 vs. 0.34 ± 0.048 s, $P = 0.018$) and response time (0.43 ± 0.033 vs. 0.75 ± 0.057 s, $P < 0.0001$) were faster for the raptor than for the mammal stimulus. Response types were run (49%) flush (45%), and hold (6%). There was no difference in response type between raptor and the mammal stimuli ($\chi2 = 1.21$, df = 2, $0.20 < P < 0.975$).

Thermal Stress Impacts

Hatching (survival) occurred in 81 of 90 (90%) control eggs, 13 of 90 (14%) non-drought eggs, and in 0 of 90 (0%) drought eggs. There was no difference in water loss of eggs during the 12 d pre-incubation period between non-drought and drought groups, $P = 0.0941$. There was no difference in water loss of eggs during incubation between any groups, $P = 0.272$.

Dry embryonic mass with residual yolk removed was not different between control and non-drought individuals, $P = 0.589$. Dry tarsometatarsus length was different between hatched individuals in control (10.81 ± 0.52 mm) and non-drought groups (11.21 ± 0.91 mm; $P = 0.0251$). Third toe length; $P = 0.374$, wing chord; $P = 0.855$, and bill length; P = 0.569 were not different between hatched individuals in control and non-drought groups. Residual wet yolk mass at hatch did not significantly differ between control and non-drought groups, $P = 0.0849$.

Time to internal and external pipping was different between control and non-drought groups, $P \leq 0.001$. Eggs belonging to non-drought groups internally pipped earlier (18.33 ± 0.82 d) than eggs in control groups (19.54 ± 0.53 d). Eggs in non-drought groups externally pipped earlier (19.15 ± 1.0 d) than eggs in control groups (19.96 ± 0.65 d) (**Figure 21**).

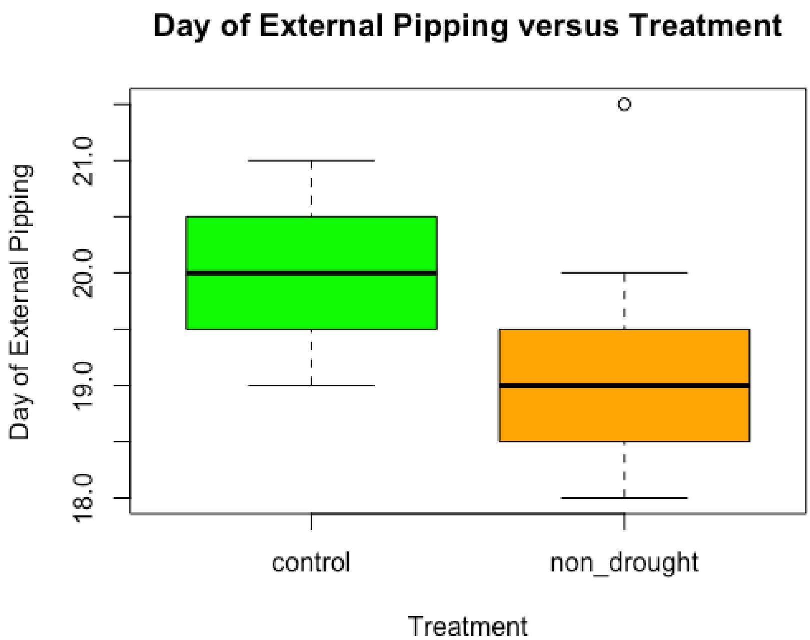

Figure 21. Time to external pipping for California valley quail exposed to a 12-day pre-incubation thermal regime, simulating natural, non-drought conditions in Texas, and control (no pre-incubation thermal regime).

Embryonic Development

Daily development of the California quail embryos is shown through candling (**Figure 22**) and images of opened eggs (**Figure 23**). California valley quail development was different from chickens and both Japanese and northern bobwhite quail, with an overall slower development than other species until day 4 (96 h). Subsequently, valley quail development lagged chickens and Japanese quail, tracking closer to, but different than, bobwhite quail until day 20 (480 h; **Figure 24**). Valley quail and Northern bobwhites both have 41 stages of development and an incubation period of 23 d. We recorded development to stage 39 or day 20 (480 h) to prevent hatching. The Japanese quail have 46 stages and an incubation period of 16.5 d (396 h). The domestic chicken also has 46 stages but hatches in 20–21 d (480–504 h). Since this study is still in progress, a complete description of development and associated embryonic characteristics will be published as the first description of embryonic development for valley quail.

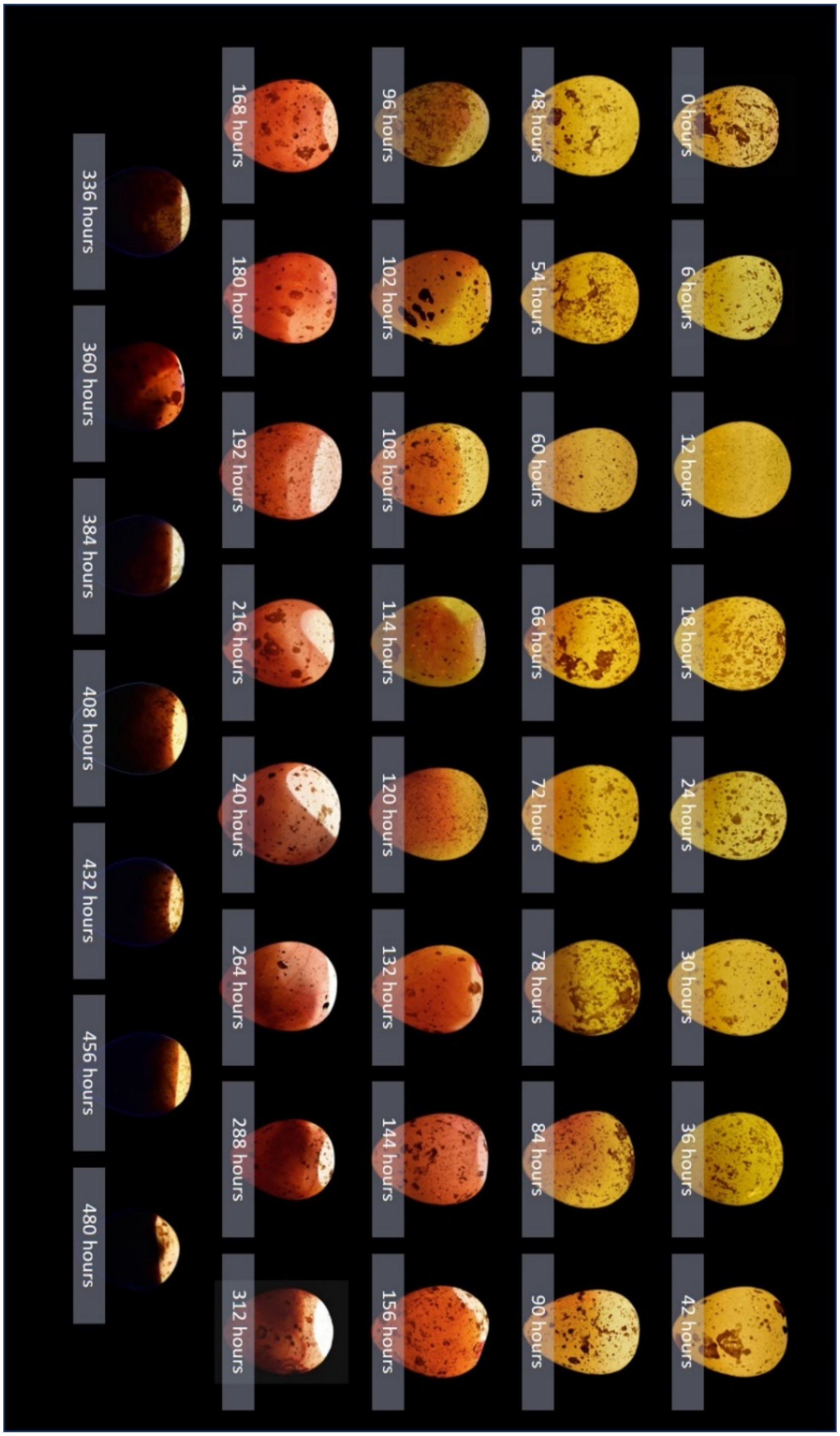

Figure 22. Developmental progression of California quail eggs as seen through candling.

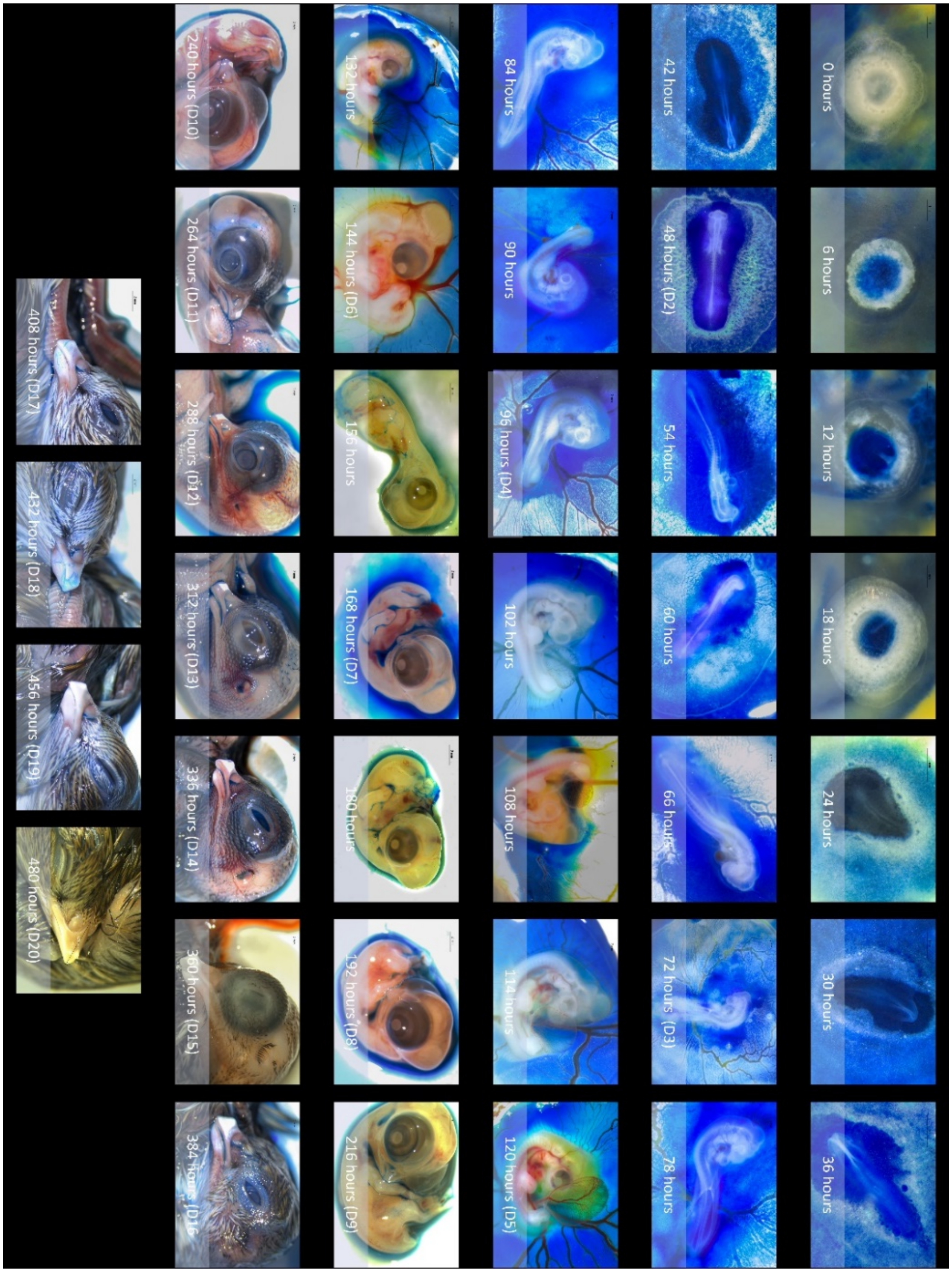

Figure 23. Developmental progression of opened California quail eggs. Blue color is methylene blue dye used to enhance contrast between embryo and surrounding fluid.

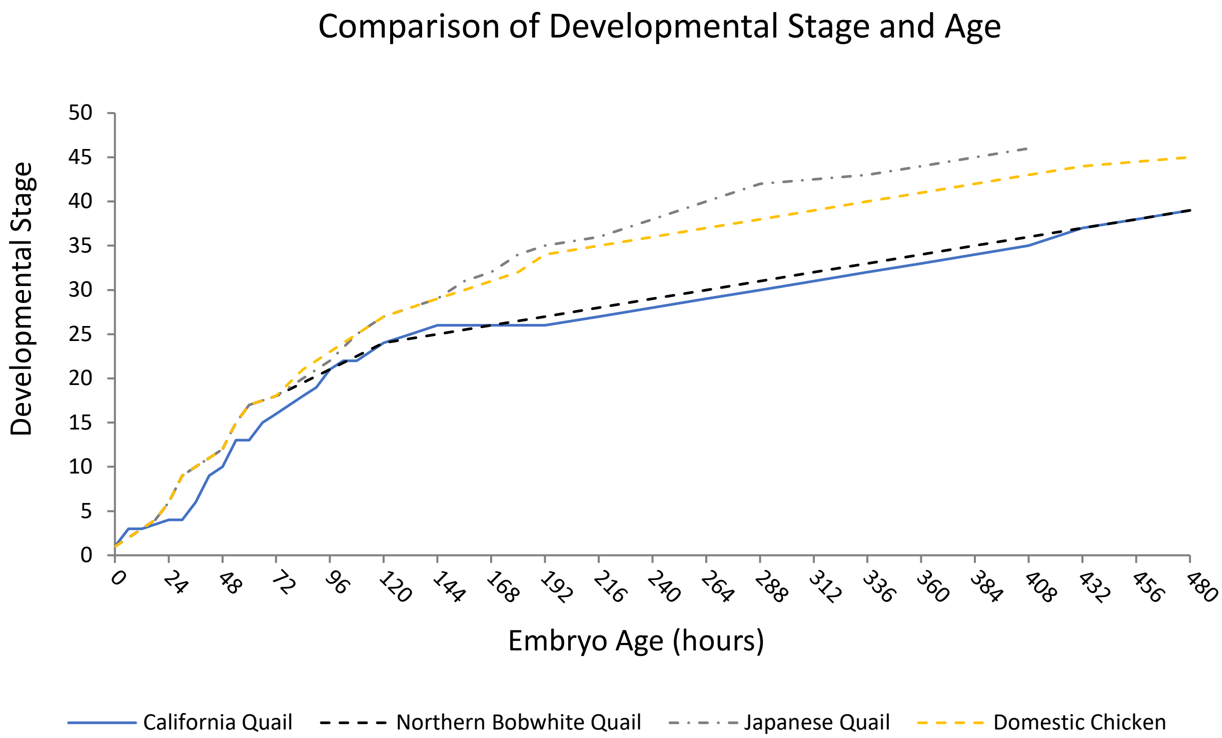

Figure 24. Developmental age compared with stage based on characteristics for the California valley quail, northern bobwhite, Japanese quail, and domestic chicken.

Translocation Weight Loss

Mean weight loss of translocated birds was 24.3 ± 1.56 g, or 14.3 ± 0.92% of body mass in 2019, and 14.3 ± 0.44 g, or 8.4 ± 0.250%, in 2020. Mean weight loss of translocated birds was lower in 2020 than in 2019 ($P < 0.001$). Females lost more weight than males in 2019 (27.4 ± 1.48 g (16.48 ± 0.87%) vs 21.9 ± 1.35 g (12.47 0.80%), respectively; $P = 0.037$), but not in 2020. There was no significant difference in weight loss between adults and juveniles, or shipments. There was a negative correlation between the initial recorded mass of the bird and the amount of mass lost (r2 = -0.15, $P < 0.001$) and percentage of mass lost (r2 = -0.08, $P < 0.001$).

For the laboratory experiment, there was no difference between any of the experimental groups. Mean weight loss for all groups was 10.9–12.8 g.

DISCUSSION

This study was the first documented translocation of wild California valley quail to Texas, demonstrating that translocating wild valley quail to Texas is feasible. This study improved on previous efforts by James et al. (2017) by (1) using wild birds, (2) selecting a release site with a sufficient quantity and quality of escape, loafing, and nesting cover, and (3) preparing the release site for translocations. We also expanded the study to improve future translocations, by recording roost sites in Texas, evaluating predators of valley quail and their nests, testing their anti-predator behavior, quantifying their developmental response to heat stress, charting the stages of development for valley quail, and determining the best feed ration for quail translocations.

We recorded high survival rate at 42 and 60 days but observed fewer quail on the release site as each year progressed, which is normal for low-density populations, especially for birds introduced to a new area with no conspecifics, or like birds. Survival estimates past 60 d were difficult to obtain due to (1) the failure and lack of performance of tracking devices, and (2) two anomalous rainfall events that resulted in large-scale flooding on the release site. The 2020 translocation was more successful than the 2019 translocation in terms of number of birds still on the study site >5 months after release. This may be due to the increased number of birds released in 2020, fewer predators observed on the study site, and the lack of major flooding events. To better evaluate survival in the future, we recommend using lightweight functional tracking devices. We had better survival from the lighter trackers. To increase survival, we recommend reducing stress during translocations, reducing predator loads at the release site, increasing usable space, and mitigating heat during reproduction and the nesting season.

Valley quail roost locations in Texas have not previously been described. Translocated valley quail in this study preferred multiple young oak trees that grew closely together and were <15 meters from escape cover. Future releases may increase site fidelity by having multiple available roost sites.

We recorded many predators of quail on cameras across the release site. Fewer predators, primarily fewer raccoons, were recorded in 2020 than 2019, which likely contributed to the increased number of quail observations. Our evaluation of predator avoidance behavior in wild valley quail showed consistent reaction times to Reyna and Newman (2018) but preliminary results did show that wild valley quail flush more than bobwhites. Flushing may be a key signal for Texas predators. More trials will be conducted in Fall 2020.

Our evaluation of thermal stress on developing valley quail, while still in progress, showed that heat during pre-incubation significantly reduces chick production. We did experience high heat loads on the release site in 2019 and 2020. The lack of major juvenile production from the releases may be explained by the combination of high temperatures during pre-incubation, high nest-predator loads (e.g., raccoons), and high stress due to translocation to a novel area. Further experiments will be conducted in Spring 2021 to evaluate these factors.

We completed the first study charting the development of California valley quail. This study demonstrated that valley quail develop at a different rate than other quail species and chickens, which are considered the standard for developmental comparison. This study will be the landmark comparison for all future developmental studies using California valley quail.

Overall, we concluded a very successful 2-year study demonstrating that translocating wild California valley quail to Texas is feasible. We observed mating, layed eggs, unbanded juveniles, and carryover. We also conducted several studies that will help improve future translocations and the study of California valley quail. As this study continues, we will seek to determine the feasibility of establishing a sustainable population.

BROADER IMPACTS

Integrating education and research is one of the major accomplishments of this study. Funding for this study enabled 8 graduate students to receive assistantships to fund their education, and 1 postdoctoral research associate to gain experience in directing large-scale research. In addition to the results of this research, 15 scientific presentations were made with accompanying published abstracts (**Table 2**), with 3 first place awards and 1 third place award. Seven news media articles were written or recorded about this research (**Table 3**) and 4 special topics courses were conducted with this study as the focus.

Table 2. Scientific Research Presentations, 2018–2020.

15.	Conley, J., J.G. Whitt, and K.S. Reyna. 2019. Predator Impacts on Wild California Quail. TAMUS Pathways Research Symposium, Laredo, Texas.
14.	Moser, E.L, J.G. Whitt, and K.S. Reyna. 2019. Thermal Stress Impacts on California Quail during Pre-incubation. TAMUS Pathways Research Symposium, Laredo, Texas.
13.	Perry, S., J.G. Whitt, and K.S. Reyna. 2019. Developmental Stages of the California Quail. TAMUS Pathways Research Symposium, Laredo, Texas.
12.	Rushing, G., J.G. Whitt, and K.S. Reyna. 2019. Roost Preference of Translocated TAMUS Pathways Research Symposium, Laredo, Texas.
11.	Vandenberg, C.N., J.G. Whitt, and K.S. Reyna. 2019. Analysis of Predator Avoidance Behavior in California Valley Quail. TAMUS Pathways Research Symposium, Laredo, Texas.
10.	Perry, S., J.G. Whitt, and K.S. Reyna. 2019. Developmental Stages of the California Quail. Statewide Quail Symposium, Abilene, Texas.
9.	Conley, J., J.G. Whitt, and K.S. Reyna. 2019. Predator Impacts on Wild California Quail. Statewide Quail Symposium, Abilene, Texas.
8.	Rushing, G., J.G. Whitt, and K.S. Reyna. 2019. Roost Preference of Translocated California Quail. Statewide Quail Symposium, Abilene, TX.
7.	Fortner, E., J.G. Whitt, and K.S. Reyna. 2019. Survival and Success of Wild California Quail in Texas. Statewide Quail Symposium, Abilene, Texas.
6.	Conley, J., J.G. Whitt, and K.S. Reyna. 2019. Predator Impacts on Wild California Quail in Texas. Annual Research Symposium, Texas A&M University Commerce.
5.	Rushing, G., J.G. Whitt, and K.S. Reyna. 2019. Nest and Roost Location Preferences of Translocated California Quail. Annual Research Symposium, Texas A&M University Commerce.
4.	Fortner, E., J.G. Whitt, and K.S. Reyna. 2019. Survival and Success of Wild California Quail in Texas. Annual Research Symposium, Texas A&M University Commerce.
3.	Norton, R.G., J.G. Whitt, and K.S. Reyna. 2019. Analysis of Predator Avoidance Behavior in California Valley Quail. Annual Research Symposium, Texas A&M University Commerce.
2.	Fortner, E. and K.S. Reyna. 2019. Survival and Success of Translocated Wild California Quail in Texas. Texas Chapter of The Wildlife Society Annual Meeting, Montgomery, Texas.
1.	Fortner, E. and K.S. Reyna. 2018. Survival and Success of Translocated Wild California Quail in Texas. 15th Annual Pathways Research Symposium, Canyon, Texas.

Table 3. Media Coverage of Research

7.	Knight, S. 2019. California Dreaming: Valley Quail Could Be The Answer To Texas' Quail Problems. Tyler Morning Telegraph.
6.	Young, A. 2019. Can these California birds bring back the quail population (and hunter) to Texas? Dallas Morning News. 24 September.
5.	TAMU System News. 2019. Texas A&M – Commerce Brings Back Quail to Texas.
4.	California Quail. TAMUS Chancellor's Video. September 18, 2019.
3.	Marks, M. 2019. How Transplanting California Quail Into Texas Could Help Save The Native Population. The Texas Standard Radio Show 24 September.
2.	Abbott, S. 2019. A&M-Commerce "Quail Professor" Says Temps Could Decimate Texas Quail Populations. Texas A&M Commerce News.
1.	Abbott, S. 2019. A&M-Commerce Professor Coordinates California Quail Translocation from Idaho to Northeast Texas. Front Porch News. 22 May.

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