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Carlos E. Gonzalez Gonzalez
*Sul Ross State University*

Louis A. Harveson
*Sul Ross State University*

Ryan S. Luna
*Sul Ross State University*

# SURVIVAL AND NESTING ECOLOGY OF SCALED QUAIL IN THE TRANS-PECOS, TEXAS

Carlos E. Gonzalez Gonzalez
Department of Natural Resource Management/Borderlands Research Institute, Sul Ross State University, East Highway 90, Alpine TX 79832, USA

Louis A. Harveson
Department of Natural Resource Management/Borderlands Research Institute, Sul Ross State University, East Highway 90, Alpine TX 79832, USA

Ryan S. Luna[1]
Department of Natural Resource Management/Borderlands Research Institute, Sul Ross State University, East Highway 90, Alpine TX 79832, USA

## ABSTRACT

Scaled quail (*Callipepla squamata*) are one of the most ecologically and economically important wildlife species in the Trans-Pecos, because they are the primary upland game bird in the Chihuahuan Desert. Using radiotelemetry, we evaluated survival (Kaplan–Meier) and nesting success of quail on 3 study sites in the Trans-Pecos, Texas: one (Santiago Mountain Ranch, central Brewster Co.) was supplemented with milo (*Sorghum bicolor*) year-round, the second (Lado Ranch, south Culberson Co.) never used supplements, and the third (Apache Ranch, central Culberson Co.) was supplemented with quail blocks. We trapped and radiocollared 164 female quail collectively across all study sites, and followed them for 2 years (May–Sep 2012–2013). There were no survival differences between years within study sites ($P = 0.985$), so we grouped data across years and compared survival between study sites. Apache Ranch had the lowest survival (55%) compared with the Santiago Mountain Ranch (76.3%) and Lado Ranch (75%). We found 47 nests across the reproductive seasons for 2012 and 2013. On average, scaled quail had high nesting success (72.6%), eggs per nest (11.6), and hatchability (91.25%). Nesting occurred from May to September with peak nesting in June and July. Timing and quantity of rain, combined with range conditions seemed to have the greatest effect on nesting performance.

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***Key words:*** Callipepla squamata*,* nesting, scaled quail, survival

Scaled quail (*Callipepla squamata*) are a common quail species in the southwestern United States and northwestern states of Mexico (Johnsgard 1969). As a consequence of the decline of bobwhite (*Colinus virginianus*) across most of their natural range (Brennan 1991, 2002; Peterson et al. 2002), scaled quail could increase their importance as a game bird and provide an additional source of income for ranchers in the Chihuahuan Desert of Texas. However, since 1960 scaled quail have shown a 50% decrease in their populations over their entire range in the United States (Brennan 1993). The most common theories for their decline include predators (Rollins 2000), overgrazing (Bridges et al. 2002), drought (Wallmo and Uzzell 1958, Pleasant et al. 2006), disease (Rollins 2000), changing habitat conditions (Schemnitz 1994, Rollins 2000), reproductive failure (Pleasant 2003), or some combination of these factors (Bridges et al. 2001). Despite this, there has been little research done with respect to basic ecology of scaled quail.

Survival and cause-specific mortality of female quail has been studied in a number of locations and habitat types across much of their range (Rollins and Carroll 2001, Cox et al. 2004, Hernandez et al. 2006, Pleasant et al. 2006), but information is lacking in arid scrubland systems, particularly in the Trans-Pecos. Adult scaled quail survival can fluctuate widely by seasons; additionally, causes of mortality may also vary between seasons (Rollins and Carroll 2001). Several studies have observed seasonal variation in survival with the lowest survival occurring during periods associated with the reproductive season and nesting activity (Rollins 2000, Lerich 2002, Pleasant et al. 2006). Miller et al. (1998) suggested that incubation and brood-rearing activities may increase susceptibility to predation, leading to greater mortality during reproductive periods.

Scaled quail populations are believed to be maintained through high reproductive output in the form of large clutch size (Schemnitz 1994). Thus, reproductive

[1] *E-mail: rluna@sulross.edu*

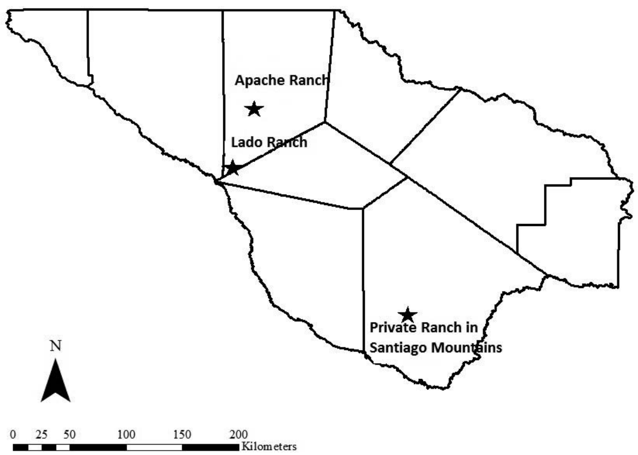


Fig. 1. Location of 3 ranches where scaled quail study sites were located in the Trans-Pecos, Texas, 2012–2013.

failure is likely to have a negative impact on population dynamics of scaled quail (Pleasant 2003). Predation has been documented to be the main cause of nest mortality (Martin 1993). Additionally, several studies have suggested there is a link between nest predation and precipitation (Palmer et al. 1993, Roberts et al. 1995). Although there is information available concerning the reproduction of scaled quail, most studies have been conducted prior to 1970 (Schemnitz 1994) and presents the disadvantage of having small sample sizes prior to the use of radiotelemetry (Schemnitz 1994, Rollins 2000). Thus, there is a great absence of knowledge on scaled quail nesting ecology (Pleasant 2003) and survival.

To approach the lack of knowledge, we initiated a study to better understand basic principles of reproduction, determine survival of female scaled quail, and identify causes of mortality that could allow land managers to promote suitable scaled quail populations.

## STUDY AREA

We conducted the study on 3 different study sites, of which 2 provided supplemental feed. All 3 areas were in the Trans-Pecos region of Texas (Fig. 1). Santiago Mountain Ranch (Site 1; 11,300 ha) was located 104 km south of Alpine, in west-central Brewster County. Rainfall averaged 280 mm/year (NOAA 2012–2013) as compared with the Texas average of 700 mm/year. The elevation of the property at its highest point was 1,670 m above sea level. Ecological sites included Basalt Hill and Mountain Desert; Flagstone Hill; Gravelly; Gravelly, Desert Grassland; Gravelly, Hot Desert Shrub; Igneous Hill & Mountain, Desert Grassland; Igneous Hill & Mountain, Desert Grassland; Loamy and Desert Grassland (NRCS 2011). Typical plant species included junipers (*Juniperus* spp.), creosotebush (*Larrea tridentata*), lechuguilla (*Agave lecheguilla*), acacia (*Acacia* spp.), ocotillo (*Fouquieria splendens*), prickly pear (*Opuntia* spp.), and mario1a (*Parthenium incanum*). Common grasses included black grama (*Bouteloua eriopoda*), blue grama (*Bouteloua gracilis*), chino grama (*Bouteloua ramosa*), and Lehmann lovegrass (*Eragrostis lehmanniana*). Most common forbs include common broomweed (*Xanthocephalum dracunculoides*), doveweed (*Croton* spp.), snakeweed (*Gutierrezia sarothrae*), and western ragweed (*Ambrosia cumanensis*). The study site contained supplemental feed with a feeder density of approximately 1 feeder/100 ha. Feeders were filled with sorghum and were available year-round. The ranch also had artificial water sources at a density of 1 waterer/200 ha.

The Lado Ranch (Site 2; 37,600 ha) was located 15 km south from Van Horn, in south Culberson County. The northern portion of the property consisted of desert flats transitioning to rolling hills with numerous draws. Southern portions included the Van Horn Mountains. Mean precipitation for the area was 305 mm with peak rainfall coming in August (NOAA 2012–2013). Ecological sites included Sandy Loam; Sandy Hills; Limestone Hill & Mountain; Loamy; Gravelly, Sandstone Hill & Mountain; and Igneous Hill & Mountain. Common shrub species included creosotebush, tarbush (*Flourensia cernua*), mariola, acacia, lecheguilla, prickly pear, ocotillo, sotol (*Dasylirion* spp.), and mesquite (*Prosopis* spp.). Primary grasses included blue grama, black grama, tobosa (*Pleuraphis mutica*), threeawns (*Aristida* spp.), tridens, and sacaton (*Sporobolus* spp.). Neither supplemental feed nor artificial water sites occurred on the Lado Ranch (Temple 2014).

The Apache Ranch (Site 3) was 50 km north east from Van Horn, in central Culberson County. Annual rainfall ranged from 280 to 380 mm (NOAA 2012–2013) across the study site with more precipitation occurring farther east and with increase in elevation across the study sites. Ecological sites included Gravelly, Limestone Hill and Mountains; Limestone Hill Dry Mixed Prairies; Loamy; Sandy Loam (NRCS 2011). Grass species include black grama, blue grama, sideoats grama (*Bouteloua curtipendula*), threeawn, tobosa, and alkali sacaton (*Sporobolus airoides;* Hatch 2007). Forbs, shrubs, and trees include fourwing saltbush (*Atriplex canescens*), creosotebush, tarbush, Apache plume (*Fallugia paradoxa*), skeleton-leaf goldeneye (*Viguiera stenoloba*), broom snakeweed, lecheguilla, ocotillo, yucca (*Yucca* spp.), and sotol were also found frequently throughout the study site (James 2013). Supplemental feed was provided as quail blocks on a year-round basis at a density of 1 block/150 ha. The ranch also had artificial water sources at a density of 1/240 ha.

## METHODS

We captured scaled quail using funnel traps with chicken scratch (grained sorghum, corn, and sunflower seeds) or sorghum between September 2011 and August 2013. We set traps in Santiago Mountain Ranch and Apache Ranch near feeding areas while we set Lado Ranch traps near areas were quail were known to be. We aged quail based on wing molt and gender by presence (female) or absence (male) of brown streaking on their neck (Cain and Beasom 1983). We allocated mortality sensitive radiotransmitters (Model AWE-Q; American

Wildlife Enterprises, Monticello, FL, USA) for 2012 and Advanced Telemetry Systems transmitters for the year of 2013 (Advanced Telemetry Systems, Isanti, MN, USA). Once we recorded measurements, we released quail at the same location as capture.

We used a directional antenna (yagi) and receiver for tracking quail and used a Global Positioning System (GPS) unit to record quail locations approximately 2 times/week. We assumed independence of locations by acquiring only 1 location in each 24-hour period (Swihart and Slade 1985). We confirmed each quail location by visual observations. We calculated survival using Kaplan–Meier staggered-entry design equation (Pollock et al. 1989). We excluded from analysis individuals that died within 1 week of capture to remove any bias that may have been associated with capture myopathy. We censored individuals who experienced radio-failure or whose signal was lost over time. We captured all females during the spring and summer (15 March to 15 May); therefore, we did not segregate age classes because all individuals were either adults ($\geq$1 yr old) or subadults ($\leq$1 yr old) being recruited into the adult population. We used a single-factor analysis of variance to evaluate differences between sites. There was no difference in survival within sites ($P = 0.985$), so we grouped samples within sites.

When we detected a mortality signal, we made attempts to recover the quail as soon as possible to determine cause of death. We grouped mortalities into 4 categories: mammalian, avian, predation caused by unknown predators, or unknown. We classified scaled quail as being killed by mammalian predators if the carcass was cached, or if we found mammalian tracks or scat on or in close proximity to the kill site (Dumke and Pils 1973, Curtis et al. 1988). We classified quail as being depredated by avian predators if the radiotransmitter was located in a shrub or tree or if the radiotransmitter presented marks typical of avian predators. If predation was evident but no identifiable predator sign was found, we classified the bird as being killed by an unknown predator. We classified deaths as unknown when scavengers had destroyed the carcass before recovery, or if there was no obvious sign of predation or injury (Carter et al. 2002).

We did not experience problems with collars (American Wildlife Enterprises, Model AWE_QLL) in year 2012. However, approximately 50% of the collars allocated in 2013 (Advanced Telemetry Systems) malfunctioned; therefore, we had problems obtaining breeding season 2013. We also used the GPS units to mark nest locations. Once we located nests, we monitored them to assess fate (nest success, no. of eggs, eggs hatchability, and timing of incubation.). We grouped causes of nest predation into 4 categories (mesomammals, snake, predation caused by unknown predators, or nest abandonment) based on condition of the nest, egg shells, and visible sign in the immediate area. We classified nests as being depredated by mesomammals if the nest was destroyed or if eggs were fragmented and the nesting female was never seen with chicks after the event, or if we found mammalian tracks or scat on or near the nest site. If predation was evident by disturbance of nest and eggs, but no identifiable predator sign was found, we classified the nest as predated by an unknown predator (Staller et al. 2005). We considered nests to be abandoned if eggs remained intact, but incubation was not completed (Rader et al. 2007).

To classify nesting habitat, we used a 1-m$^2$ frame (Daubenmire 1959) to measure ground cover (relative percentages of bare ground, litter, succulents, grasses, forbs, and woody vegetation $<$2 m in ht and $>$2 m in ht). We divided specific cover percentage into categories as follows: 1 = 0–1%, 2 = 1.1–5%, 3 = 5.1–25%, 4 = 25.1–50%, 5 = 50.1–75%, and 6 = 75.1–100%. We also documented species composition in a 1-m$^2$ frame placed directly over the nest to determine primary nesting plant structure. Also, we estimated lateral visual obstruction using a Robel pole (Robel et al. 1970) placed at the nest center. We recorded the lowest reading at 10-cm intervals that were $\geq$50% visible in each of the 4 cardinal directions and calculated an average of the 4 readings to provide a single value for each nest site.

## RESULTS

On Santiago Mountain Ranch in 2012, we trapped 153 scaled quail (60 M, 72 F, 21 unidentified gender). We radiocollard 17 females and obtained a survival estimate of 75% for the 2012 breeding season. In 2013, we trapped 129 quail (25 M, 62 F, 42 unidentified gender). We radiocollard 58 females and obtained a survival estimate of 70% for the 2013 breeding season.

On the Lado Ranch in 2012, we trapped 149 scaled quail (59 M, 55 F, 35 unidentified gender). We radiocollared 8 females and obtained a survival estimate of 78% for the 2012 breeding season. In 2013, we trapped 62 quail (32 M, 30 F). We radiocollared 30 females and obtained a survival estimate of 70% for the 2013 breeding season.

On Apache Ranch in 2012, we trapped 78 scaled quail (4 M, 19 F, 55 unidentified gender). We radiocollared 19 females and obtained a survival estimate of 47% for the 2012 breeding season. In 2013, we trapped 70 quail (32 F, 38 unidentified gender). We radiocollared 32 females and obtained a survival estimate of 54% for the 2013 breeding season.

Kaplan–Meier survival analysis showed a marked decrease in survival mainly in the months of April through July (Fig. 2). Primary causes of mortalities were raptors, mesomammals, and mortality due to human disturbance (Fig. 3).

We documented 47 total scaled quail nests in 2012 and 2013. We did not include Apache Ranch in analysis of nesting because of problematic data. Santiago Mountain Ranch nests ($n = 30$) had an average of 11.25 eggs/nest, 85% egg hatchability, and 71% nesting success. Five of the nests were predated by mesomammals. Two nests were abandoned, possibly because of inadvertent harassment of females caused by our telemetry efforts. Lado Ranch nests ($n = 17$) had an average of 11.5 eggs/nest, 97.5% hatchability, and 47% nesting success. Six of the nests were destroyed by predators and 2 nests were unsuccessful because the females were killed by predators.

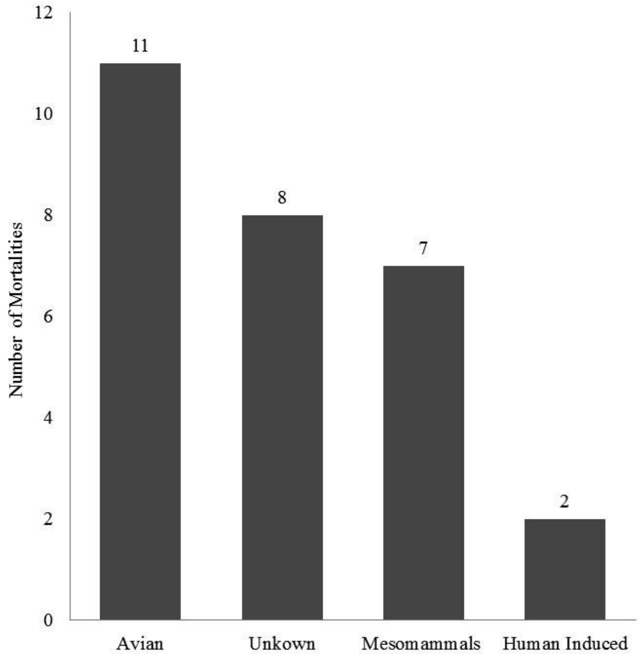


Fig. 2. Cause–specific mortality of scaled quail during reproductive season (Mar–Sep) on 3 restudy sites in the Trans-Pecos, Texas, 2012–2013.

Nest predation ($n$ = 15) was mainly attributed to snakes ($n$ = 6; 40%) because snakes predated 5 nests (only Lado Ranch; Fig. 4). Mesommals accounted for 33.3% ($n$ = 5) of nest predations. Some females ($n$ = 4; 8.5%) abandoned their nest, possibly because of disturbance induced by our telemetry efforts. We did not document predation from unknown cause in either study site.

Categorical values (1 = least amount to 5 = greatest amount) of vegetation on nest locations for both ranches averaged 3.3 for bare ground, 3.0 for litter, 2.3 for forbs, 3.6 for grasses, and 4.0 for succulents (Fig. 5). On Santiago Mountain Ranch, scaled quail selected a greater diversity of plants used for nesting. Quail on Lado Ranch seemed to have selected for sotol (33.76%) and lechuguilla (20.77%) (Fig. 6). Other plants used for nesting include ocotillo (6.49%), chino grama (6.49%), prickly pear (6.49%), Spanish dagger (*Yucca schidigera;* 5.19%), tasajillo (*Cylindropuntia leptocaulis;* 3.89%), whitethorn acacia (*Vachellia constricta;* 3.89%), tarbush (3.89%), sacahuista (*Nolina microcarpa;* 2.59%), creosotebush (2.59%), mesquite (2.59%), and javelina bush (*Condalia ericoides;* 1.29%). Nesting peaked in July and ranged from April to September for a few cases (Fig. 7). Timing of nesting did not vary across study sites and seemed to be triggered by initiation of rainfall.

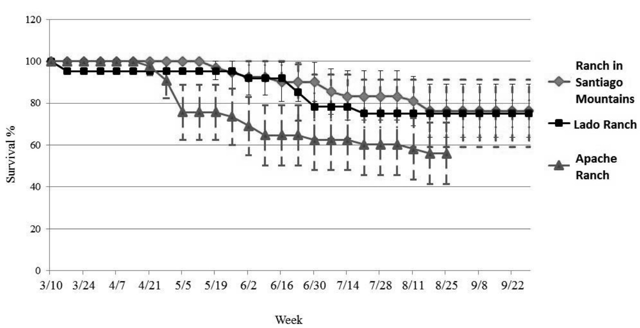


Fig. 3. Kaplan–Meier (Pollock et al. 1989) survival estimates and 95% confidence intervals for female scaled quail during 2012 and 2013 reproductive seasons combined at 3 study sites in the Trans-Pecos, Texas, 2012–2013. There was no significant year.

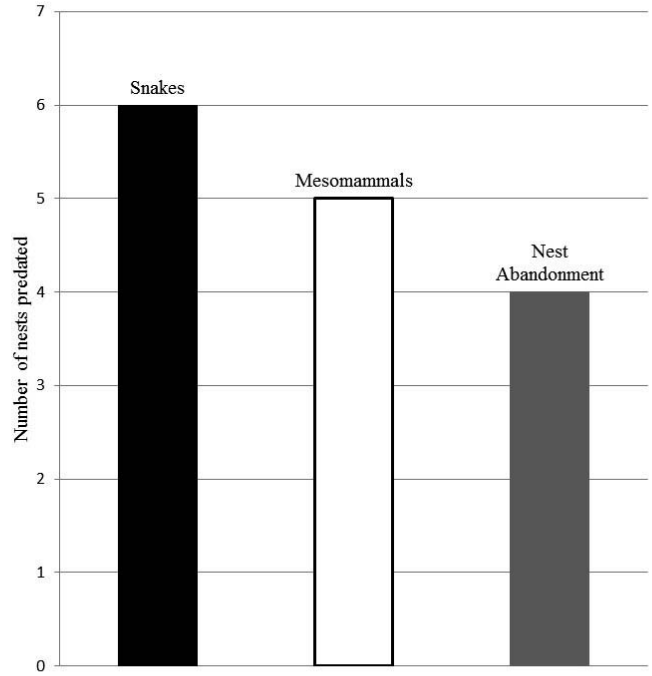


Fig. 4. Causes of failure for scaled quail nests during reproductive season on 3 study sites in the Trans-Pecos, Texas, 2012–2013.

## DISCUSSION

Compared with other studies (Rollins et al. 2006, Pleasant et al. 2006) we observed average to higher survival rates than have been reported in the past. There

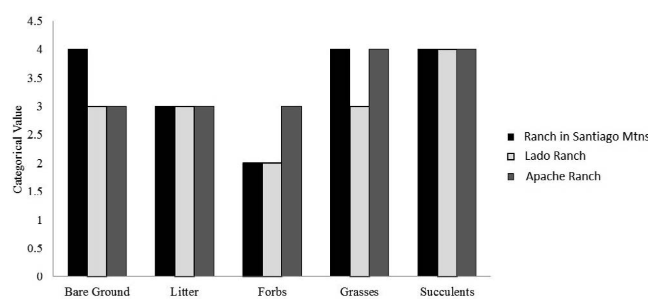


Fig. 5. Composition of vegetation present in each nest represented in categorical values (1 = least amount to 5 = greatest amount) for scaled quail nests found on 3 study sites in the Trans-Pecos, Texas, 2012–2013. Percent value for each category was grouped into categorical values for better interpretation because of lack of consistency when collecting data.

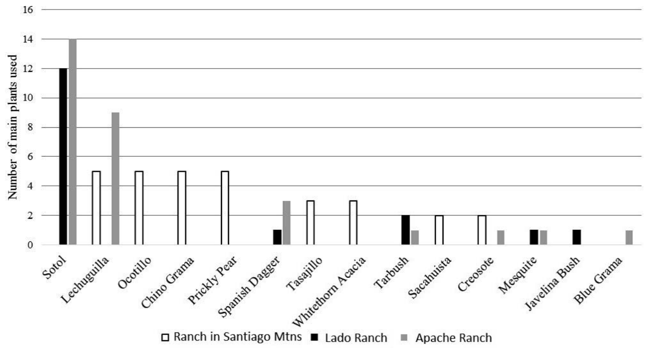


Fig. 6. Main plants used for nesting sites by scaled quail on 3 study sites in the Trans-Pecos, Texas, 2012–2013.

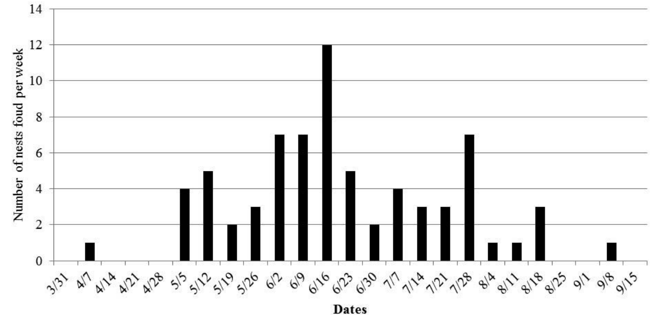


Fig. 7. Dates of nests found during scaled quail reproductive season on 3 study sites in the Trans-Pecos, Texas, 2012–2013.

was only a 1% difference in survival between Santiago Mountain Ranch and Lado Ranch. The greatest difference in survival was observed at Apache Ranch, with 19% lower survival than Lado Ranch and Santiago Mountain Ranch. Our research indicated that survival in Apache Ranch compares closely to the results from Pleasant et al. (2006), who reported survival of female scaled quail during the breeding season that ranged from 30% to 43%. Rollins (2000) estimated survival rates of female scaled quail to be 70%, which were similar to those we recorded at Santiago Mountain Ranch (76%) and Lado Ranch (75%). We noticed a decrease in survival beginning mid-April until mid-July, after which survival stabilized for all study sites. The decrease of survival may be due to a combination of factors such as avian predators, increased vulnerability of females on nests, and increased temperatures (21° C during spring to 35° C during the summer; NOAA 2012–2013).

During 2012 and 2013, we found the first nest in the first week of April and recorded the latest nest the first week of September. Brown (1989) observed that scaled quail would delay nesting season until summer rains in late June, July, or even August. Nesting season has been also acknowledged to last from April through September (Russell 1931, Bent 1932). The extended nesting season could increase the opportunity for successful nesting despite temporarily adverse weather conditions (Schemnitz 1961).

Literature reported highly variable nesting success for scaled quail; Leopold (1933) reported 8.3% and Schemnitz (1961) documented 14% success. However, these studies did not use telemetry equipment. Studies using radiotelemetry have shown consistently higher nesting success (36%, Lerich 2002; 44% and 64%, Pleasant 2003). These results are likely due to the difference in methodology and use of telemetry equipment as opposed to ecological differences. In this study, we documented high nest success ranging from 47% (Santiago Mountain Ranch) to 73% (Lado Ranch). Despite different reports on percentage of successful nesting (Russell 1931, Schemnitz 1961, Lerich 2002), hatching percentages seem not to vary between other studies and our results. Results from previous studies have reported 90% (Schemnitz 1968), 95% (Pleasant 2003), and 100% (Tharp 1971). In our study hatching rate was 85% (Santiago Mountain Ranch) and 97.4% (Lado Ranch), which falls between results from the previous mentioned studies. Predation seemed to be the most common cause of nest failure.

## MANAGEMENT IMPLICATIONS

Weather conditions are believed to be a cause of short term and possibly long-term population trends of scaled quail (Schemnitz 1994). Studies support the theory that spring–summer rainfall is correlated with scaled quail population fluctuations (Wallmo and Uzzell 1958). The amount and timing of precipitation seems to have a pronounced influence on nesting success and annual population growth. Without optimum range conditions existing when rainfall occurs, maximum benefits for this species cannot be realized in terms of annual scaled quail numbers (Pleasant et al. 2006).

Differences in vegetation structure and composition may lead to greater survival of incubating and brooding females (Pleasant 2003). Heterogeneity of vegetation in an area may prevent predators from developing search patterns for grass-nesting birds (Martin 1988). A possible way to decrease loss of scaled quail populations is to increase cover and adequate loafing habitat (Rollins et al. 2006). This makes it a challenge to manage adequate vegetation structure, plant species composition, and arrangement of these plant communities because they may have a profound effect on survival of scaled quail populations (Pleasant et al. 2006).

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