National Quail Symposium Proceedings

Volume 6 Article 47

2009

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An Evaluation of Short-term Mesocarnivore Control for Increasing Hatch Rate in Northern Bobwhites

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We evaluated the efficacy of short-term trapping on scent-station visitation rates for some nest predators and survival of artificial nests with chicken eggs at 4 sites in west Texas from 1998-2001. Trapping of predators was conducted with cage traps for 30 days just prior to nest initiation (mid-May through mid-June) at a trap density of 1 trap/20 ha. Each site included a treatment (trapped) and control (non-trapped) area that comprised approximately 250 ha. Scent stations were employed before and after trapping to assess impacts of trapping on predator activity/abundance. Simulated nests (using 3 chicken eggs) were established 1-2 days after trapping ended, and monitored weekly to estimate visitation rate. We removed an average of 69 mesomammals per year ($n = 274$ across all sites), within a 30-day-trapping period. We detected no consistent declines in scent-station visitation rates of target species before or after trapping. We did not detect an increase in survival of artificial nests. We conclude that short-term trapping efforts on small areas used in this study did not reduce the overall predator community enough to affect scent-station visitation rates or survival of artificial nests.

Citation: Lyons EK, Frost J, Rollins D, Taylor B, Scott C. 2009. An evaluation of short-term mesocarnivore control for increasing hatch rate in northern bobwhites. Pages 447 - 455 in Cederbaum SB, Faircloth BC, Terhune TM, Thompson JJ, Carroll JP, eds. Gamebird 2006: Quail VI and Perdix XII. 31 May - 4 June 2006. Warnell School of Forestry and Natural Resources, Athens, GA, USA.

Key words: *Colinus virginianus*, mesomammal abundance, nesting success, northern bobwhite, predator control, Rolling Plains, Texas

Introduction

Northern bobwhite (*Colinus virginianus*, hereafter bobwhite) populations have declined over most of their historic range since 1980 (Sauer et al. 2001) and at an average of 4.9% annually since 1981 in Texas. Although reasons for the decline are unclear, factors implicated in this decline include habitat fragmentation, land-use changes, weather patterns, fire ants (*Solonopsis invicta*), and an increase in mesomammal predators (Rollins and Carroll 2001, Rollins 2002, Brennan et al. 2005).

Nest survival of bobwhites reported in the literature averaged 28% (Rollins and Carroll 2001) and occasionally nesting success is <20% because of depredation (Lehmann 1984, Ortega et al. 1998, Sloan et al. 1998, Clawson and Rotella 1998). Given the impact of predation on quail survival and nesting success, it seems logical that intensive predator control would increase quail density. However, previous research in South Texas demonstrated that intensive year-long predator control had little effect on quail survival and nesting success (Beasom 1974, Guthery and Beasom 1977).

Given the potential impacts of nest predation by mesomammals (Rollins and Carroll 2001), we tested the efficacy of short-term-selective-predator trapping immediately before nesting season as a means of increasing survival of simulated nests. Predator control efforts usually have little impact on long-term mesomammal densities (Balser et al. 1968). However, intensive predator control efforts immediately before nesting season may offer a window of opportunity for quail to nest with reduced disturbance from predators. We assessed survival of artificial nests on trapped and non-trapped areas and changes in predator populations following short-term control efforts.

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Study Area

Study 1. 1998-1999.

This study was conducted in Tom Green and Coke counties, Texas. This study was conducted using 2 sites, each with 2 study plots (trapped and non-trapped) in 1998 and then repeated with new study sites in 1999. Each study plot was approximately 250 ha and was separated by $\geq$3.0 km.

Site 1 (Angelo State University Management, Instruction, and Research Center) was located approximately 6 km north of San Angelo in Tom Green County, Texas. Site 2 (North Concho Ranch) was located approximately 13 km north of San Angelo in Tom Green County, Texas. Site 3 (Johnson Ranch) was located approximately 6 km northwest of Water Valley in Coke County, Texas. Site 4 (Clark and D Cross ranches) was located approximately 4 km northwest of Water Valley in Coke and Tom Green counties, Texas. All sites were rangeland dominated by an overstory of honey mesquite (*Prosopis glandulosa* var. *glandulosa*) and understory of mixed grasses [mostly tobosa grass (*Hilaria mutica*)], curly mesquite (*Hilaria belangeri*), and prickly pear cactus (*Opuntia* spp.). Thirty-year normals for Coke and Tom Green counties indicate that Study 1 was completed during a drought. Annual precipitation was 32.9 cm in 1998, in Tom Green County and 34.3 cm in 1999, as reported by the National Weather Service at Mathis Field, San Angelo, Texas. Precipitation for 1999 in Coke County was 36.2 cm as reported by the National Weather Service at Water Valley, Texas.

Study 2. 2000-2001.

The second study was initiated in Parker County, Texas, in 2000 and replicated in Coleman County, Texas in 2001.

Parker County - Site 1 was enclosed within a 2.0-m chain-link "game-proof" fence. This pasture is approximately 600 ha and was used for grazing by cattle and exotic ungulates. Study plot 1 of site 2 was located in a 1,900-ha pasture used solely for cattle grazing. Study plot 2 of site 2 was located on a separate portion of the ranch about 20 km southwest of the main ranch property. The treatment area was in the middle of a pasture approximately 800 ha in size. Trapped areas were separated from non-trapped areas by 2.0 km. Sand plum (*Prunus gracilis*), little bluestem (*Schizacharium scoparium*), and mesquite were common. Pecan (*Carya illinoensis*) and live oak (*Quercus virginiana*) dominated the riparian lowlands. Annual precipitation was 95.3 cm in 2000, and was 11.7 cm above 30-year normals as reported by the National Weather Service at Weatherford, Texas.

Coleman County - All sites were grazed by cattle and dominated by mesquite and prickly pear. As a result of drought, low numbers of bunchgrasses were present, and most areas in 2001 were dominated by annual forbs such as broomweed (*Xanthocephalum dracunculoides*), and basketflower (*Centaurea americana*), and annual grasses (*Bromus* spp. and *Hordeum pusillum*). Annual precipitation was 69.9 cm in 2001, as reported by the National Weather Service in Coleman, Texas.

Methods

Mesomammal Control

We targeted specific mesocarnivores such as raccoons (*Procyon lotor*) and skunks (*Mephitis mephitis*) for removal using the most humane means available (e.g., cage traps). Coyotes (*Canis latrans*) and bobcats (*Lynx rufus*) were not targeted because their home range encompassed areas greater than the study sites. Trapping methods also did not facilitate the capture of larger carnivores. Trapping methods were constrained by landowner requirements. For example, spotlighting or calling for predators, such as skunks and coyotes was not allowed.

Trapping was initiated just prior to the nesting season of bobwhites (i.e., late-April) and continued for 30 days. In 2000, trapping was extended 4 days as a result of flooding. Cage traps (36 cm x 36 cm x 122 cm) were placed along pasture roads across each trapped area at a density of approximately 1 trap/20 ha. Chicken eggs were used as bait for the first 15-day period of trapping, while canned cat food was used during the second 15-day period. Traps were checked daily between 0700-1000 hours. Mesomammals were sacrificed with a .22 rifle to the base of the skull under an animal use protocol approved by the Care of Animal Laboratory and Wildlife Use Committee at Texas A&M University (SPR-0198-922). Specimens were deposited in the Angelo State Natural History Collection (ASNHC) as voucher specimens for Tom Green, Coke, Parker and Coleman counties, Texas.

Mesomammal Abundance/Activity

We estimated mesomammal abundance/activity with scent station surveys before trapping and at 2 and 120 days post-trapping on all sites (Woods 1959). Scent stations consisted of a 1.0-m circle of crushed lime on bare ground placed on alternating sides of the road at 0.5-km intervals (Linhart and Knowlton 1975, Martin and Fagre. 1988). Previous studies suggested that movements by coyotes along roads are typically less than 0.5 km (Hodges 1975, Roughton and Sweeny 1982). Given that ranges of coyotes are greater than that of targeted species (i.e., raccoons, skunks, opossums), we feel that distances between stations are sufficient for independence. A cotton swab soaked in bobcat urine was placed in the middle of the plot as a scent attractant (Morrison 1981, Carroll et al. 1999). Bobcat urine was used as a general attractant for multiple species (Conner et al. 1983). Any bias due to the scent attractant used was assumed to be the same across all sites. Each station was observed for 2 consecutive nights (Roughton and Sweeny 1982). Lime and scent attractant were refreshed as necessary.

For these studies, each area had a different number of stations because the length of roads differed among study areas. Furthermore, all study areas contained only a single road that traversed the area. As a result, each area consisted of only 1 transect with a different number of stations. To eliminate differences is sample size of scent stations, visitation rates of targeted species were standardized to 100-scent station nights (SSN).

Simulated Nests

The selection of nesting substrate for simulated nests was restricted to suitable nest clumps meeting the definitions by Lehmann (1984). A prickly pear was deemed suitable for nesting if it was >1 m in size and had grass growing inside the plant (Slater et al. 2001). Three medium-sized, unwashed chicken eggs were placed inside each nest. In order to alleviate bias from human scent at the nest site, latex gloves were worn while constructing the nest and handling the eggs. A 2.0-cm steel washer was placed in the bottom of the nest to facilitate location of the nest site in the event all eggs were removed by predators. Nests were monitored every 7 d for 28 d. Any nest with 1 or more egg(s) missing or moved >40 cm was classified as depredated. After 2 weeks, eggs in surviving nests were replaced to minimize scent resulting from rotting.

No attempt was made to identify individual nest predators. Staller et al. (2005) indicated that diagnostic sign is unreliable for identifying predators of bobwhite nests. Some studies also have shown that predators often leave similar remains suggesting that identification of predators from eggshell remains is equivocal (Hernandez et al. 1997, Marini and Melo 1998, Lariviere 1999). Simulated nests were constructed after post-trap scent stations were completed to measure rates of nest depredation on all sites. The number of transects and placement of nests varied slightly across studies.

Study 1. 1998-1999 - Six transects of 12 simulated nests/transect were placed on each treatment area (Ortega et al. 1998). Transects were 600 m long and placed 200 m apart. Transects were randomly located throughout each study site, and placed perpendicular to an existing fence or road. Nests were placed every 50 m along the transect line and 10 m either to the right or left of the transect line. Nests were located alternately in either a suitable bunchgrass or a clump of prickly pear.

Study 2. 2000-2001 - Eight transects of 6 nests each were established at each site. Transects were approximately 300 m long, and transect lines were approximately 200 m apart. In 2000, nests were constructed in suitable bunchgrass cover ≥10 m off the transect line. As a result of low numbers of suitable bunchgrass clumps in 2001, nests were placed in the nearest clump of grass or prickly pear resembling suitable nesting cover.

Vegetation Sampling

Potential nesting sites were estimated using a belt transect on all sites in order to assess the similarities or differences in vegetative communities among study areas. Simulated nest transects (described above) served as transects for the estimates. Each transect was walked with the observer's arms outstretched and suitable nest sites that were rooted within this belt were counted (Slater et al. 2001). The number of potential grass and prickly pear nests were counted and converted to nests/ha.

Statistical Analyses

Simulated nest survival was analyzed using 2-way Analysis of variance (ANOVA). Sites were pooled and data were analyzed by treatment and year. Linear regression analysis was used to determine if relationships between survival of simulated nests and nest site availability exist. Logistic regression was used to determine if nest site abundance was a good predictor of survival of artificial nests. Sites were pooled and each year was analyzed independently. All statistical analyses were calculated with SPSS Inc. (SPSS Inc. 2002).

Results

Mesomammal Control

1998 - A total of 120 mesomammals was removed; 66 from trapped study plot of site 1, and 54 from the trapped study plot of site 2. Raccoons were the species trapped most frequently on both sites (36%, n = 24 on Site 1; 57%, n = 31 on Site 2). Other species trapped on Site 1 included opossum (*Didelphis virginianus*, n = 16), striped skunk (n = 16), and additional mammals (n = 8). Other species trapped on Site 2 included opossum (n = 10), striped skunk (n = 9), and additional mammals (n = 4).

1999 - A total of 99 mesomammals was removed; 27 from the trapped study plot of site 3, and 72 from the trapped study plot of site 4. Raccoons were the species most frequently trapped on Site 3 and Site 4 (66%, n = 18; 72%, n = 52, respectively). Other species trapped on Site 3 included striped skunk (n = 6), and miscellaneous mammals (n = 3). Other species trapped on Site 4 included striped skunk (n = 7), and miscellaneous mammals (n = 13).

2000 - A total of 41 mesomammals was removed; 30 from the trapped study plot of site 1, and 11 from the trapped study plot of site 2. Raccoons were the species trapped most frequently on site 1 (n = 20). Other species included armadillos, (*Dasypus novemcinctus*, n = 3) and opossums (n = 7). Armadillos were trapped most frequently on site 2 (n = 6), followed by opossums (n = 4), and raccoons (n = 1). All predators were removed from the riparian areas of the study plots. Predator trapping in the open grasslands proved unsuccessful. No skunks were trapped on either site.

2001 - Predator removal was less successful with only 14 mesomammals removed from the study site; 6 from study plot 1 and 8 from study plot 2. Raccoons were the only species trapped on site 1. Raccoons and skunks were trapped from site 2, but in low numbers (4 of each species). All predators were taken from traps located within close proximity of water (e.g., stock tanks).

Mesomammal Abundance

1998 - Scent stations did not show decreases in number of mesomammal visitations after trapping (Table 1). Further increases in visitations by target species were demonstrated with 120-day post trap scent stations. Raccoons increased from 5.6 and 5.8 visits/100 SSN to 39.5 and 11.6 visits/100 SSN on sites 1 and 2, respectively.

1999 - While numbers of predator visitations decreased overall on scent stations after trapping on both sites 3 and 4, there were no consistent declines in predator abundances on trapped areas. Where 1 species, such as raccoons decreased, skunks may have increased. As in 1998, predator numbers rebounded to or exceeded pre-trap levels by 120-day post trap scent stations.

2000 - Scent stations indicated a decrease in the number of targeted mesomammal visitations after trapping on site 5; however, visitations increased on

Table 1: Pre- and 2-day post-trap scent station visits for targeted species [standardized to visits/100 scent station nights (SSN)] and number of mesomammals removed on respective sites are reported for 8 treatment sites in the Rolling Plains of Texas, 1998 - 2001.

Year	Site	Treatment	County	Scent station visits/100 SSN Pre-trap	2-day Post trap	Mesomammal trapping Animals removed
1998	1	Trapped	Tom Green	13.9	17.5	66
	2	Trapped		15.0	18.8	54
1999	3	Trapped	Tom Green/Coke	35.3	26.9	27
	4	Trapped		40.7	38.1	72
2000	5	Trapped	Parker	45.4	12.5	30
	6	Trapped		10.0	23.5	11
2001	7	Trapped	Coleman	63.3	33.3	6
	8	Trapped		24.1	13.3	8

site 6 (Table 1). The result of low trapping numbers of some target species (e.g., raccoons, opossums) and the inability to remove others (i.e., skunks) suggest that values showing decreases in mesocarnivore abundances may be misleading (Table 1).

2001 - Scent station visitations suggested that raccoons and skunks were the major species present. There were decreases in visitations on both trapped sites; however, trapping results were so low (Table 1) that post-trap scent station values were not representative of the mesomammal community.

Simulated Nest Survival and Suitable Nest Site Availability

1998 - Average percent of artificial nests that survived 28 days was lower on control versus treatment sites (control [n = 12, $\bar{x}$ = 2.75, SD = 5.44], treatment [n = 12, $\bar{x}$ = 9.58, SD = 12.14]). However, trapping of specific mesomammals did not significantly increase survival of artificial nests (F = 3.165, df = 1, P = 0.089). Greater nest site availability (i.e., suitable nest sites/ha) on control ($\bar{x}$ = 983, SE = 165) versus treatment areas ($\bar{x}$ = 716, SE = 129) suggested a possible relationship between artificial nest survival and nest site availability. A linear relationship between survival of artificial nests and number of suitable nest sites was indicated (F = 4.657, df = 1, P = 0.042) although little variation in artificial nest survival was explained by nest site availability (R^2 = 0.175). Logistic regression was used to determine if nest site abundance was a good predictor of artificial net survival. No relationship between nest site abundance and survival of artificial nests was found on either control (X^2 = 0.017, df = 1, P = 0.897) nor treatment sites (X^2 = 0.142, df = 1, P = 0.707) thus suggesting that nest site abundance is not a good predictor of artificial nest survival.

1999 - Average percent of artificial nests that survived 28 days was higher on control versus treatment sites (control [n = 12, $\bar{x}$ = 43.33, SD = 26.96], treatment [n = 12, $\bar{x}$ = 36.75, SD = 23.27]). Trapping of specific mesomammals did not significantly increase survival of artificial nests (F = 0.410, df = 1, P = 0.529). Greater nest site availability (i.e. suitable nest sites/ha) on control ($\bar{x}$ = 809, SE = 136) versus treatment areas ($\bar{x}$ = 728, SE = 139) suggested a possible relationship between artificial nest survival and nest site availability. A linear relationship between survival of artificial nests and number of suitable nest sites was indicated (F = 6.311, df = 1, P = 0.020) although little variation in artificial nest survival was explained by nest site availability (R^2 = 0.223). Logistic regression was used to determine if nest site abundance was a good predictor of artificial net survival. No relationship between nest site abundance and survival of artificial nests was found on the control (X^2 = 1.56, df = 1, P = 0.211) site. However, a significant relationship was observed on the treatment (X^2 = 6.57, df = 1, P = 0.010) site suggesting that nest site abundance can be a predictor of artificial nest survival.

2000 - Average percent of artificial nests that survived 28 days was higher on control versus treatment sites (control [n = 16, $\bar{x}$ = 73.96, SD = 22.73], treatment [n = 16, $\bar{x}$ = 18.76, SD = 24.24]). Trapping of specific mesomammals had a significant effect on survival of artificial nests, however, trapping did not cause an increase in the survival of artificial nests (F = 44.156, df = 1, P = 0.000). Greater nest site availability (i.e., suitable nest sites/ha) on control ($\bar{x}$ = 2262, SE = 271) versus treatment areas ($\bar{x}$ = 930, SE = 187) suggested a possible relationship between artificial nest survival and nest site availability. A linear relationship between survival of artificial nests and number of suitable nest sites was indicated (F = 4.184, df = 1, P = 0.050) although little variation in artificial nest survival was explained by nest site availability (R^2 = 0.122). Logistic regression was used to determine if nest site abundance was a good predictor of artificial net survival. No relationship between nest site abundance and survival of artificial nests was found on either control (X^2 = 3.81, df = 1, P = 0.051) nor treatment sites (X^2 = 0.047, df = 1, P = 0.829) thus suggesting that nest site abundance is not a good predictor of artificial nest survival.

2001 - Average percent of artificial nests that survived 28 days was higher on control versus treatment sites (control [n = 16, $\bar{x}$ = 84.37, SD = 12.85], treatment [n = 16, $\bar{x}$ = 40.63, SD = 31.67]). Trapping of specific mesomammals had a significant effect on survival of artificial nests; however, trapping did not cause an increase in the survival of artificial nests (F = 29.078, df = 1, P = 0.000). Greater nest site availability (i.e. suitable nest sites/ha) on control ($\bar{x}$ = 554, SE = 106) versus treatment areas ($\bar{x}$ = 236, SE = 47) suggested a possible relationship between artificial nest survival and nest site availability. No relationship between survival of artificial nests and number of suitable nest sites was indicated (F = 1.999, df = 1, P = 0.168, R^2 = 0.062). Logistic regression was used to determine if nest site abundance was a good predictor of artificial net survival. No relationship between nest site abundance and survival of artificial nests was found on either control (X^2 = 0.374, df = 1, P = 0.541) nor treatment sites (X^2 = 0.324, df = 1, P = 0.569) suggesting nest site abundance is not a good predictor of artificial nest survival.

Discussion

Predator control does not appear to be a viable method of increasing survival of nests when applied to small areas over short periods of time. Landowner constraints on trapping methods affect the feasibility of predator removal as a mechanism to increase survival of nests. Small-scale trapping efforts also are affected by the behavior of the animal (i.e., trap happy, trap shy). In portions of these studies, the inability to remove skunks was exacerbated by the inability to adjust trapping methods. Landowners lacking the means and area necessary for large-scale-predator control should not rely on predator removal as a mechanism for increasing survival of nests.

In western Texas, medium-sized carnivores, or mesomammals, such as foxes (*Urocyon cinereoargenteus* and *Vulpes vulpes*), raccoons, feral cats, and skunks are primary nest predators (Dolbeer et al. 1996, Hernandez et al. 1997, Slater et al. 2001). Removal of these predators may cause non-target species such as coyotes to switch prey items and focus primarily on nests. Prey switching may explain the higher artificial nest survival on control versus treatment sites in 3 of 4 years.

Fragmentation of habitats may exacerbate nest depredation. Small fragmented areas may allow for concentration of predators, which would increase their likelihood of encountering a nest. Artificial nests in prairies <15 ha were depredated more (37.0%) than those in larger prairies (13.9%) during a study in southwestern Missouri (Burger et al. 1994). Once a nest had been located, it is possible that predators focused their search efforts in the general vicinity. This effect may be compounded by habitat fragmentation. Placing nests along transect lines may also have aided predators in locating nests, thus increasing nest depredation. However, we assumed that any bias due to nest placement or nest density was spread evenly across all sites.

It also has been hypothesized that predators follow human scent to aid in the location of nests (Bayne and Hobson 1997, Sloan et al. 1998). Skagen et al. (1999) reported that nest predation was not higher when human scent was present. Donalty and Henke (2001) demonstrated that attempts to conceal scent were ineffective. We also assumed that any bias due to human scent left near nests was spread evenly across all sites.

Slater et al. (2001) suggested a threshold of nesting sites (≥754 nest sites / ha) at which the effects of nest depredation were mitigated. Although there was 1 site where a statistically significant relationship between simulated nest survival and nest site availability was indicated (e.g., 1999 $P = 0.010$), this result does not appear to be biologically significant. Therefore, nest site abundance does not appear to be a good predictor of artificial nest survival. Although nest site availability numbers were higher on all sites than the threshold established by Slater et al. (2001), intensive year-round grazing, and below average rainfall for several years may have contributed to high nest depredation. Intensive grazing during drought periods prior to the studies being initiated resulted in nests placed in the already fragmented bunchgrass area likely becoming even more vulnerable to depredation. Even though grazing pressure was reduced on the Coleman County area during the study, the intensity of the drought may not have allowed for the reparation of nesting habitat.

Management of brush and nesting habitat may be the most important factor in quail ecology. Proper amounts of both can increase nest success and survival. Drought and overgrazing decrease the amount of nesting cover, thus decreasing nest survival. High numbers of nest sites may not provide all the protection quail need to decrease nest depredation. For instance, nest success was greater in Kansas when quail were able to nest in tall clumps of grass (Taylor et al. 1999). This suggests that quality may be as important as quantity of nest sites.

Overall, a partial removal of mesomammal predators over a short period of time did not appear to affect the predator population, nor increase survival of artificial nests. Given that some nest predators were not targeted in these studies, we are uncertain of the effectiveness of predator removal. Given the result of our data, we suggest that a 1-month-trapping period is insufficient in areas where bobwhites nest.

Acknowledgments

We thank the Moncrief and Knox families for land access. We thank Quail Unlimited and the Moncrief family for funding support. We thank G. Anderson, J. Brooks, R. Fleeman, T. Harter, J. Luster, T. L. Russell, and M and M. Wills for assistance in the field. We thank Ken Cearley for technical support.

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