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INTERACTIONS OF RAPTORS AND LESSER PRAIRIE-CHICKENS AT LEKS IN THE TEXAS SOUTHERN HIGH PLAINS

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ABSTRACT.—We examined behavioral interactions of raptors, Chihuahuan Ravens (*Corvus cryptoleucus*), and Lesser Prairie-Chickens (*Tympanuchus pallidicinctus*) at leks in the Texas Southern High Plains. Northern Harriers (*Circus cyaneus*) and Swainson's Hawks (*Buteo swainsoni*) were the most common raptors observed at leks. Only 15 of 61 (25%) raptor encounters at leks (0.09/hr) resulted in a capture attempt (0.02/hr). Mean (± SD) time for Lesser Prairie-Chickens to return to lekking behavior following a raptor encounter was 4.2 ± 5.5 min suggesting the disturbance had little influence on lekking behaviors. Lesser Prairie-Chickens engaged in different escape behaviors depending on raptor species and, generally, did not respond to ravens suggesting they are able to assess different predation risks. The raptors in our study area posed little predation risk to lekking prairie-chickens. Behavioral disturbance at leks appears minimal due to the lack of successful predation events, low raptor encounter rates, and short time to return to lekking behavior. *Received 22 August 2010. Accepted 3 January 2011.*

Lesser Prairie-Chicken (*Tympanuchus pallidicinctus*) populations have declined throughout much of their historic range (Crawford and Bolen 1976, Hagen et al. 2004). Taylor and Guthery (1980) estimated that ≥90% decrease had occurred in their occupied range since the 1800s. Currently, small populations exist in parts of Colorado, Kansas, New Mexico, Oklahoma, and Texas (Hagen and Giesen 2005). The population decline has resulted in Lesser Prairie-Chickens being designated as a candidate species by the U.S. Fish and Wildlife Service for protection under the Endangered Species Act of 1973 (USDI 2008).

Lekking species may be more susceptible to predation as they are congregated, focused on mating, and exposed (Hartzler 1974). Lehmann (1941:39) stated that "Prairie chickens on the courtship grounds seemed more intent on mating than on self-preservation; consequently, losses from predation were probably heaviest at mating time." Wolfe et al. (2007) reported male mortality was highest during peak lekking activity and suggested the cause may be male conspicuousness and/or predators focusing on lekking activity, although they did not report how many males were actually killed on leks. Schroeder and Baydack (2001) speculated that habitat degradation at prairie grouse leks may have exacerbated predation risks. Few studies, however, have investigated predation on North American prairie grouse leks (e.g., Berger et al. 1963, Hartzler 1974, Boyko et al. 2004) and no study has specifically identified predation on leks as a major source of mortality.

Direct predation and disturbance of breeding activities may limit reproduction of birds (Cresswell 2008). Baydack and Hein (1987) reported female Sharp-tailed Grouse (*T. phasianellus*) avoided disturbed leks (e.g., presence of humans, dogs, vehicles, snow fences, propane exploders, scarecrows, and radio noises). Alternatively, congregation of birds at leks may reduce predation risk due to increased probability of detecting a predator before it becomes a serious threat. The predation risk for each individual decreases as the number of individuals in a group increases, as long as predation events do not increase as well (Boyko et al. 2004). Flushing as a group may confuse a predator and make it harder to select an individual (Lack 1968, Wittenberger 1978). Leks are generally in the same location year after year, possibly because they have proven to be safe in the past (Lack 1968).

Raptors have been identified as predators of Lesser Prairie-Chickens (Campbell 1950, Haukos

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1988, Haukos and Broda 1989, Hagen and Giesen 2005, Hagen et al. 2007, Wolfe et al. 2007). Specific to our study area, Northern Harriers (*Circus cyaneus*) have been observed predating Lesser Prairie-Chickens in eastern New Mexico (Campbell 1950) and the Texas Southern High Plains (Haukos and Broda 1989). Our objectives were to examine: (1) encounter rates and incidences of raptor predation at Lesser Prairie-Chicken leks, and (2) behavioral responses of prairie-chickens to different raptor species and Chihuahuan Ravens (*Corvus cryptoleucus*) at leks in the Texas Southern High Plains.

METHODS

Study Area.—Our study occurred on private lands in Cochran and Yoakum counties in the Texas Southern High Plains ecoregion (Llano Estacado). The topography is flat to gently undulating with small vegetated dunes. The dominant vegetation in most areas was shinnery oak (*Quercus havardii*) intermixed with sand sagebrush (*Artemisia filifolia*) and grasses. The major land use in this area was agriculture with a high proportion of the area under intensive cultivation and cattle production. Oil development occurred throughout the study area with Yoakum County producing 23,730,647 barrels of oil in 2007 (Railroad Commission of Texas 2010).

Field Methods.—We used a combination of direct observation and video-recording to monitor raptor–Lesser Prairie-Chicken encounters at leks during spring 2007 and 2008. We used four leks known by landowners and Texas Parks and Wildlife Department staff in 2007, and included three new leks located by roadside surveys in 2008 (Behney 2009). We excluded two of the 2007 leks due to logistical constraints in 2008. Direct observations were conducted from small, camouflaged, pop-up style blinds placed among vegetation at the edge of the lek, or from a vehicle parked within 15 m of the lek. We arrived at leks before prairie-chickens were present; typically >1.5 hrs before sunrise and remained stationary for the duration of the observation period. We used binoculars and spotting scopes to monitor prairie-chickens and identify predators. We did not depart the lek until 20 min after the last prairie-chicken departed each morning.

We placed two video-recording systems at each lek being video-monitored. One system was placed sufficiently far from the lek to ensure the entire area was recorded (far) and the second system was placed close to or zoomed in (close) to record behaviors of grouse and predators. This camera arrangement was not possible on one lek and we used two camera systems placed the same distance from the lek but at different angles.

Each video-recording system consisted of a security style camera connected to a video camera recorder (VCR) or digital video camera recorder (DVDR). Camera systems were powered by a 12-volt deep-cycle marine battery connected to a power inverter, and enclosed in weatherproof housing. A power strip was connected to the inverter, into which the VCR and the security camera were connected. The VCR or DVDR recorded real-time video to facilitate identification of flying raptors and behavior of prairie-chickens.

Recording occurred 2–4 days/week at each lek. We recorded lek activities from 0.5 hrs before sunrise to 2–4 hrs post-sunrise and from 2 hrs before sunset to 0.5 hrs after sunset. All tape and battery changes were at mid-day (1100–1400 hrs) when prairie-chickens were not present to minimize risk of disturbance. We used an editing VCR to review the collected video footage of activities at leks. We initially viewed the far camera recordings to identify behaviors (predator, flushing, disturbance) and then viewed the close up tape for a more in-depth view. We reviewed both tapes completely in the case where two cameras were placed the same distance from the lek.

We noted the time, date, lek, species, age (if possible), raptor approach type, and prairie-chicken response type if a raptor or raven was observed. The raptor or raven had to be within 35 m of the lek (visually estimated) to be included in the analysis. At this distance the raptor or raven and Lesser Prairie-Chickens should have been able to see each other. We classified raptors to the lowest taxonomic level possible when we could not identify the raptor species. We pooled Peregrine Falcon (*Falco peregrinus*), Prairie Falcon (*F. mexicanus*), Merlin (*F. columbarius*), and unknown falcons (*Falco* spp.) in a ''falcon'' group and Red-tailed Hawk (*Buteo jamaicensis*), Ferruginous Hawk (*B. regalis*), and unknown buteos (*Buteo* spp.) in a ''buteo'' group. We pooled Cooper's Hawks (*Accipiter cooperii*) and Sharp-shinned Hawks (*A. striatus*) into an ''accipiter'' group.

Statistical Analysis.—Raptor approach types were classified as predation attempt, course, perch, or fly-by. ''Predation attempts'' were obvious dives at or chases of Lesser Prairie-

Chickens. ''Coursing'' was a low, slow glide over the landscape in search of prey, typical of Northern Harriers. ''Perch'' was noted any time a raptor landed in view of the camera, and a ''fly-by'' was when the raptor paid no apparent attention to prairie-chickens as it flew over. Responses of prairie-chickens to raptors and ravens were categorized as no response, squat, partial flush, or flush. We considered a raptor/raven–prairie-chicken encounter as eliciting ''no response'' if we could not observe any alteration in behavior of the grouse when the encounter occurred. ''Squat'' consisted of seeking cover or flattening against the ground. ''Partial flush'' consisted of at least one but not all prairie-chickens flushing from the lek, and ''flush'' occurred when every grouse on the lek flushed.

We noted the time when lekking behavior ceased to when at least two Lesser Prairie-Chickens returned to lekking behavior. Raptor encounter rates were calculated by dividing the number of raptors observed at leks by the hours of lek observation or recording during which prairie-chickens were present. We used an exact rate ratio test assuming Poisson counts in Program R to compare raptor encounter rates (R Development Core Team 2008, Fay 2009).

We used a *G*-test for goodness of fit to compare frequency of occurrence of different raptor species observed at leks to the overall raptor community in the area following Sokal and Rohlf (1995). We used frequency of occurrence at leks by Swainson's Hawks, Northern Harriers, falcon species, and buteo species (not including Swainson's Hawks) as observed values. Expected values were computed from data collected during standardized raptor surveys in the area (Behney 2009). Only surveys conducted during February, March, and April were included and were pooled over years. The total number of each raptor species or species group observed during surveys was divided by the total number of all raptors recorded during surveys. We then multiplied this proportion by the total number of raptors observed at leks to sum to the same total as raptors seen at leks, while maintaining the same proportion of each species/species group.

We used Chi-square tests of independence (Conover 1999) to assess independence among approach, species, and response. We also used a Chi-square test to assess differences in behavioral response of Lesser Prairie-Chickens to raptor encounters compared to raven encounters. We used a Kruskall-Wallis test (Conover 1999) to compare prairie-chickens return times associated with different raptor species because the data were not normally distributed. We categorized the lekking season into five 2-week intervals to assess temporal variations in encounter rates and species dynamics: 1 = 9 to 22 March, 2 = 23 March to 5 April, 3 = 6 to 19 April, 4 = 20 April to 3 May, and 5 = 4 to 17 May.

RESULTS

Raptor Encounter Rates.—We conducted 155 hrs of direct observation at seven leks while Lesser Prairie-Chickens were present between 24 February and 21 May 2007 and 2008. We observed 21 raptors and 37 ravens on or near leks while prairie-chickens were present. We recorded 495 hrs of real-time video footage on seven leks while prairie-chickens were present from 3 April through 9 June 2007 and 8 March through 22 May 2008. We observed 40 raptors and 104 ravens on or near leks while prairie-chickens were present during the video recordings. There was no difference in encounter rates between viewing platform (direct observations = 0.14 raptors/hr, video = 0.08 raptors/hr; $P = 0.08$) and the data were pooled (overall = 0.09 raptors/hr). Study leks averaged 12.3 males (range = 6–19). We did not observe any successful predation events on the video or through direct observations.

Northern Harriers ($n = 30$) were the most commonly observed raptor at leks followed by Swainson's Hawks ($n = 11$), other buteos ($n = 9$), falcons ($n = 5$), and accipiters ($n = 2$). We were unable to identify five raptors to the genus level. We observed one additional Peregrine Falcon encounter at a lek during direct observations but failed to note the time Lesser Prairie-Chickens departed the lek and were unable to assess the duration of lek attendance by prairie-chickens that morning. This encounter was included in behavioral analyses but not in encounter rate calculations. Encounter rates peaked during the second 2-week interval and steadily decreased to their lowest rates during the last interval (Fig. 1). Proportions of individual raptor species or species groups at leks diverged from that expected based on the observed raptor community ($X_3^2 = 45.4$, $P < 0.001$). More Northern Harriers (contribution to overall G-statistic = 28.92), fewer Swainson's Hawks (−12.08), and more falcons (8.20) were observed at leks than expected based on the raptor community present in the area.

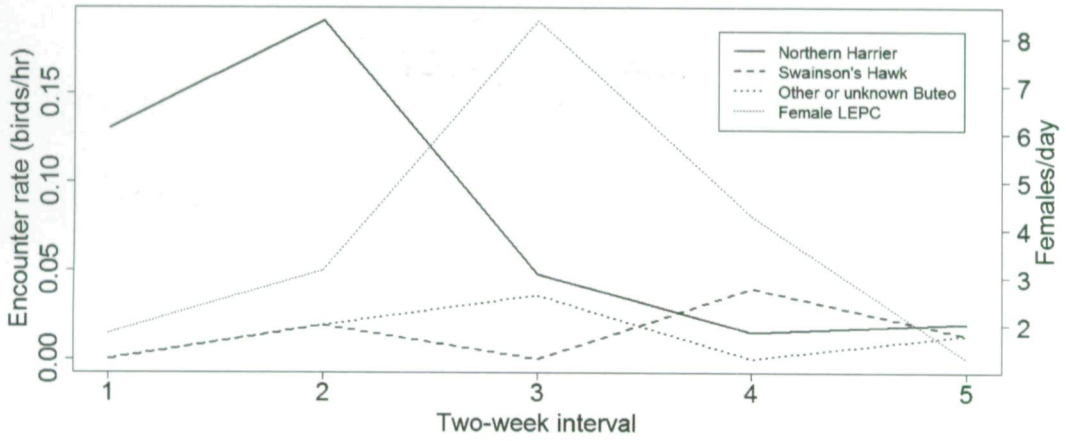

FIG. 1. Species and species group-specific raptor encounter rates (birds/hr) and female Lesser Prairie-Chicken visitation rate (females/day) for 2-week intervals throughout the lekking season in the Texas Southern High Plains, 2007–2008. Two-week interval start dates were: 1 = 9 March, 2 = 23 March, 3 = 6 April, 4 = 20 April, and 5 = 4 May.

Raptor Approach Types.—Coursing was the most commonly observed approach type (44% of encounters) used by raptors, followed by perching (24%), fly by (16%), and predation attempt (16%). We detected 15 predation attempts on Lesser Prairie-Chickens, primarily by Northern Harriers (n = 7), Swainson's Hawks (n = 3), and falcons (n = 2). Accipiters, other buteos, and unknown raptors accounted for one predation attempt each. Northern Harriers were the most common raptor observed coursing whereas buteo hawks were more commonly seen perching. Approach type was related to raptor species (X_6^2 = 17.25, P = 0.008). Northern Harriers perched less than expected, Swainson's Hawks attempted to prey upon prairie-chickens more than expected, and other buteos perched more than expected.

Lesser Prairie-Chicken Response Types.—Some or all Lesser Prairie-Chickens flushed in 62% of all raptor encounters. However, prairie-chicken response was associated with raptor type (Northern Harrier, buteo, or falcon; X_6^2 = 14.5, P = 0.02). Harriers and buteos were more likely to elicit flushing responses (75 and 73% of all responses, respectively). In contrast, three of five falcon encounters elicited squat responses from prairie-chickens (Fig. 2). This is likely a low estimate because flushes often occurred only after

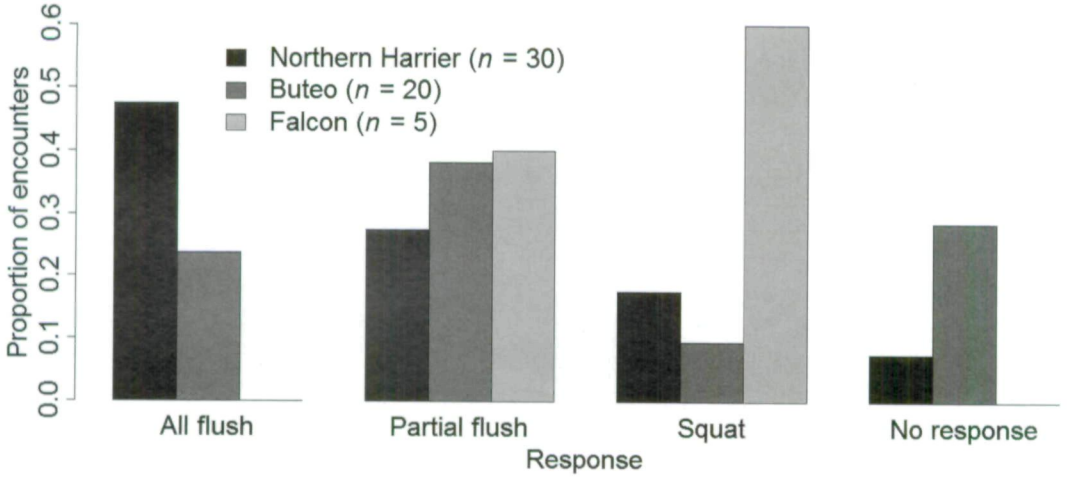

FIG. 2. Lesser Prairie-Chicken response to Northern Harriers (n = 30), buteos (including Swainson's Hawks, n = 20), and falcons (n = 5) encountered at leks in the Texas Southern High Plains, 2007–2008.

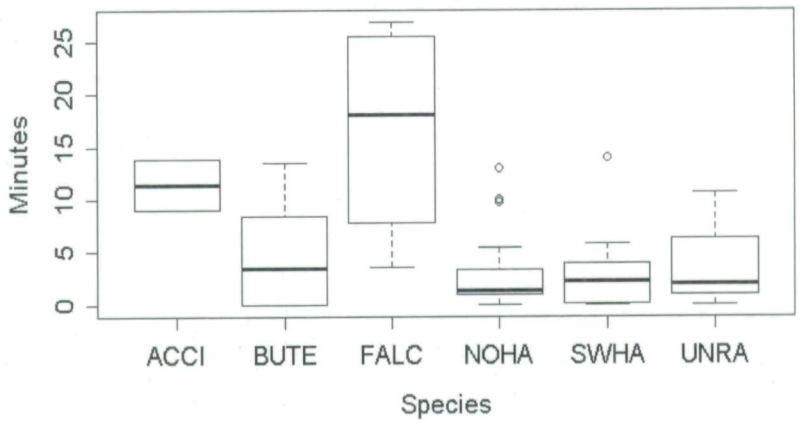

FIG. 3. Lekking behavior return time for at least two Lesser Prairie-Chickens following an accipiter, other or unknown buteo, falcon, Northern Harrier, Swainson's Hawk, and unknown raptor encounters at leks in the Texas Southern High Plains, 2007–2008. Boxes represent interquartile range about the median. Whiskers represent the most extreme datum point that is no more than the range × the interquartile range from the box. Asterisks represent outliers in the data.

falcons repeatedly dove at prairie-chickens. The initial response in all falcon encounters was for prairie-chickens to squat and stay on the ground; however, after repeated swoops by the falcon, a few eventually flushed in two encounters and were recorded as partial flushes.

Lesser Prairie-Chickens are apparently able to differentiate risk posed by different avian predators and respond accordingly. Raptors elicited some type of response in 85% of encounters whereas only 9% of raven encounters elicited a response ($X_1^2 = 138$, $P < 0.001$). Mean (± SD) time for at least two prairie-chickens to be displaying at leks following a raptor encounter was 4.22 ± 5.5 min. Return times were different following encounters involving different raptor species (Kruskal-Wallis Rank Sum Test, $X_5^2 = 11.895$, $P = 0.036$; Fig. 3).

DISCUSSION

Sage- and prairie grouse spend a substantial amount of time on leks (typically 3–4 hrs/day, Hagen and Giesen 2005) during the spring. Their congregation and exposure could lead to increased predation risk (Lehmann 1941, Hartzler 1974, Schroeder and Baydack 2001). Our data suggest raptor predation on Lesser Prairie-Chickens at leks is uncommon. We did not observe any successful predation events at leks despite 650 hrs of data from when Lesser Prairie-Chickens were on leks.

Our results are similar to those from other studies of lekking species as successful predation events on leks were rare or absent (Berger et al. 1963, Moran 1966, Haukos and Broda 1989). Encounters classified as predation attempts in our study were rare (0.02 attempts/hr). This suggests use of a lek mating system may limit predation events and may be an efficient anti-predator strategy (Boyko et al. 2004).

Northern Harrier encounters peaked during the 2-week interval of 23 March to 5 April, after which they began migrating from the study area (Fig. 1; Behney 2009). Buteonine hawk encounters were low throughout the lekking season but peaked during the interval starting 6 April, which corresponded to migrants moving through the area while some wintering hawks were still present (Behney 2009, Preston and Beane 2009). Swainson's Hawk encounters were low throughout the season but peaked during the interval starting 20 April. This corresponded to arrival of Swainson's Hawks migrating from the southern hemisphere (England et al. 1997, Behney 2009) and establishment of breeding territories in the study area. The period of peak female attendance at leks corresponded to dramatic decreases in raptor encounters at leks (Fig. 1). Haukos (1988) reported a similar observation that peak female Lesser Prairie-Chicken attendance at leks occurred just after most raptors had migrated through the area.

Lesser Prairie-Chicken responses to predation attempts appear to correspond to the hunting strategies of different raptor species. Northern Harriers and buteo hawks (including Swainson's

Hawks) typically capture prey on the ground and would likely have difficulty overtaking and catching a prairie-chicken in the air (Macwhirter and Bildstein 1996, England et al. 1997). These raptor species elicited more flushing responses from prairie-chickens. Falcons evolved to overtake and capture prey in the air (Webster 1944, White 1962), and elicited more of a squatting response and an observable hesitancy to flush by prairie-chickens. This suggests Lesser Prairie-Chickens are able to assess the threat posed by different raptors species and have evolved the appropriate behavioral response.

We are confident we detected all raptor predation attempts on Lesser Prairie-Chickens at leks during monitoring and video-recording periods. However, it is possible that we missed some raptor fly-bys or coursing that occurred behind or over the blind or camera. We believe any observer effect on raptor presence or behavior was minimal due to the small size of the blind, our arrival well before sunrise, and that we remained stationary throughout the observation period. Encounter rates were higher for direct observation than video-recording, suggesting observer presence was not inhibiting raptor presence.

Raptors were not a source of mortality or marked disturbance of Lesser Prairie-Chickens while on leks in our study. This suggests mortality of lekking Lesser Prairie-Chickens from raptor predation is not a factor contributing to population declines.

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LITERATURE CITED

BAYDACK, R. K. AND D. A. HEIN. 1987. Tolerance of Sharp-tailed Grouse to lek disturbance. Wildlife Society Bulletin 15:535–539.

BEHNEY, A. C. 2009. Predation and reproductive behavior of Lesser Prairie-Chickens at leks in the Texas Southern High Plains. Thesis. Texas Tech University, Lubbock, USA.

BERGER, D. D., F. HAMERSTROM, AND F. N. HAMERSTROM JR. 1963. The effect of raptors on Prairie Chickens on booming grounds. Journal of Wildlife Management 27:778–791.

BOYKO, A. R., R. M. GIBSON, AND J. R. LUCAS. 2004. How predation risk affects the temporal dynamics of avian leks: Greater Sage-Grouse versus Golden Eagles. American Naturalist 163:154–165.

CAMPBELL, H. 1950. Note on the behavior of Marsh Hawks toward Lesser Prairie Chickens. Journal of Wildlife Management 14:477–478.

CONOVER, W. J. 1999. Practical nonparametric statistics. John Wiley and Sons, New York, USA.

CRAWFORD, J. A. AND E. G. BOLEN. 1976. Effects of land use on Lesser Prairie Chickens in Texas. Journal of Wildlife Management 40:96–104.

CRESSWELL, W. 2008. Non-lethal effects of predation in birds. Ibis 150:3–17.

ENGLAND, A. S., M. J. BECHARD, AND C. S. HOUSTON. 1997. Swainson's Hawk (*Buteo swainsoni*). The birds of North America. Number 265.

FAY, M. 2009. Package rateratio.test: exact rate ratio test. R package Version 1.0-1. http://CRAN.R-project.org/package=rateratio.test

HAGEN, C. A. AND K. M. GIESEN. 2005. Lesser Prairie-Chicken (*Tympanuchus pallidicinctus*). The birds of North America. Number 364.

HAGEN, C. A., B. E. JAMISON, K. M. GIESEN, AND T. Z. RILEY. 2004. Guidelines for managing Lesser Prairie-Chicken populations and their habitats. Wildlife Society Bulletin 32:69–82.

HAGEN, C. A., J. C. PITMAN, B. K. SANDERCOCK, R. J. ROBEL, AND R. D. APPLEGATE. 2007. Age-specific survival and probable causes of mortality in female Lesser Prairie-Chickens. Journal of Wildlife Management 71:518–525.

HARTZLER, J. E. 1974. Predation and the daily timing of Sage Grouse leks. Auk 91:532–536.

HAUKOS, D. A. 1988. Reproductive ecology of Lesser Prairie Chickens in West Texas. Thesis. Texas Tech University, Lubbock, USA.

HAUKOS, D. A. AND G. S. BRODA. 1989. Northern Harrier (*Circus cyaneus*) predation of Lesser Prairie Chicken (*Tympanuchus pallidicinctus*). Journal of Raptor Research 23:182–183.

LACK, D. 1968. Ecological adaptations for breeding in birds. Chapman and Hall, London, United Kingdom.

LEHMANN, V. W. 1941. Attwater's Prairie Chicken, its life history and management. USDI, Fish and Wildlife Service, North American Fauna 57.

MACWHIRTER, R. B. AND K. L. BILDSTEIN. 1996. Northern Harrier (*Circus cyaneus*). The birds of North America. Number 210.

MORAN, R. J. 1966. Predation on a Greater Prairie Chicken by a Goshawk. Auk 83:137.

PRESTON, C. R. AND R. D. BEANE. 2009. Red-tailed Hawk (*Buteo jamaicensis*). The birds of North America. Number 52.

R DEVELOPMENT CORE TEAM. 2008. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. http://www.R-project.org.

RAILROAD COMMISSION OF TEXAS. 2010. Oil and gas production data. http://webapps.rrc.state.tx.us/PDQ/changeViewReportAction.do?viewType=MonthlyTotals

SCHROEDER, M. A. AND R. K. BAYDACK. 2001. Predation and the management of prairie grouse. Wildlife Society Bulletin 29:24–32.

SOKAL, R. R. AND F. J. ROHLF. 1995. Biometry: the principles and practice of statistics in biological research. Third Edition. W. H. Freeman and Co., New York, USA.

TAYLOR, M. A. AND F. S. GUTHERY. 1980. Status, ecology, and management of the Lesser Prairie Chicken. USDA, Forest Service, General Technical Report RM-77. Rocky Mountain Station, Fort Collins, Colorado, USA.

U.S. DEPARTMENT OF INTERIOR (USDI). 2008. Endangered and threatened wildlife and plants; review of native species that are candidates for listing as endangered or threatened. Federal Register 73:75176–75244.

WEBSTER JR., H. 1944. A survey of the Prairie Falcon in Colorado. Auk 61:609–616.

WHITE, C. M. 1962. Prairie Falcon displays accipitrine and circinine hunting methods. Condor 64:440–441.

WITTENBERGER, J. F. 1978. The evolution of mating systems in grouse. Condor 80:126–137.

WOLFE, D. H., M. A. PATTEN, E. SHOCHAT, C. L. PRUETT, AND S. K. SHERROD. 2007. Causes and patterns of mortality in Lesser Prairie-Chickens *Tympanuchus pallidicinctus* and implications for management. Wildlife Biology 13:95–104.