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# LARK SPARROW (*Chondestes grammacus*) ABUNDANCE, DENSITY, AND THE EFFECTS OF MICROHABITAT FACTORS ON NEST SUCCESS IN CEMETERIES IN SOUTHERN OKLAHOMA

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*Abstract*—Since 1966, Lark Sparrow (*Chondestes grammacus*) populations have undergone population declines and range shifts. In 2015-2016, we collected data on Lark Sparrow abundance, density, nest success, brood parasitism by Brown-headed Cowbirds (*Molothrus ater*), and nesting microhabitat in cemeteries in southern Oklahoma. Lark Sparrow abundance (0.67-1.29/point) was greater in our study than in other studies across the species' range; however, Lark Sparrow density (35.2-52.2/40 ha) was similar to other studies. Lark Sparrows laid an average of 3.2 eggs/nest and fledged an average of 1.1 fledglings/nest in southern Oklahoma cemeteries. Brood parasitism was documented in only 10% of nests, which is lower than previous rates of 19-45.5% in southern Oklahoma. Nest height was positively related to Lark Sparrow nest success and fledging rate and percentage of artificial material was positively related to the number of fledglings.

## INTRODUCTION

The Lark Sparrow's (*Chondestes grammacus*) current nesting range extends across the central and western United States and southernmost parts of the interior of British Columbia, Alberta, and Saskatchewan, Canada (Martin and Parish 2000). Lark Sparrows are common summer residents in Oklahoma (Sutton 1967, Baumgartner and Baumgartner 1992). Lark Sparrow breeding range has contracted since the start of the North American Breeding Bird Survey (hereafter, BBS) in 1966 (Sauer *et al.* 2015). The contraction of the breeding range was likely influenced by habitat loss due to reforestation and urbanization, especially in the eastern US (Askins 1993, Knopf 1996). Lark Sparrow populations in the United States declined range-wide by 61.2% from 1966 to 1993 (Price *et al.* 1995). From 1966 to 2015, in Oklahoma, Lark Sparrows declined 1.2% annually (Sauer *et al.* 2015). Conversely, Lark Sparrow populations are increasing in the Pacific Northwest and Ohio Valley (Sauer *et al.* 2015).

Lark Sparrows prefer structurally open habitats containing scattered trees or shrubs (Fitch 1958, Knopf 1996). Lark Sparrows will forage in overgrazed cattle pasture, recently disturbed areas, and other early successional habitat (Fitch 1958, Zimmerman 1993). In Kansas, Lark Sparrows required 6 ha to meet their territorial requirements (Fitch 1958). Fitch (1958) found that Lark Sparrows defended a mean area of 0.013 ha around the nest site for foraging and nesting behavior. Lark Sparrows nest in savanna and scrub-shrub habitat and build their nests in short woody vegetation (e.g., post oak, *Quercus stellata*) or on the ground (Wiens 1963, Newman 1970, Martin and Parrish 2000, Lusk *et al.* 2003). In Oklahoma, Newman (1970) found that Lark Sparrows constructed 30% of nests on the ground, whereas 70% of nests were above ground in post oak, black willow (*Salix nigra*), and eastern red cedar (*Juniperus virginiana*).

Lark Sparrow nests have a range-wide mean clutch size of 4 eggs (range 3-6, McNair 1985). In southern Oklahoma, Newman (1970) recorded Lark Sparrow mean clutch size of 3.4 eggs (range 1-4) and documented a 41.2% nest success rate in which ≥1 young fledged/nest. Newman (1970) documented 54.8% nest failure due to predation in southern Oklahoma. Predation by mammals and snakes accounted for 33.3% and 66.6% of Lark Sparrow nest loss, respectively (Newman 1970). In Oklahoma, Lark Sparrows overlap ranges with black rat snakes (*Pantherophis obsoletus*) and racers (*Coluber constrictor*) which are likely predators of Lark Sparrow nests (Newman 1970). In Kansas, Brush and Ferguson (1986) documented a single Lark Sparrow nest depredated by a massasauga rattlesnake (*Sistrurus catenatus*). In southern Oklahoma, ground nests also are subject to predation by red imported fire ants (*Solenopsis invicta*; pers. obs.).

Data for Brown-headed Cowbird (*Molothrus ater*) brood parasitism rates on Lark Sparrow nests are conflicting. Friedmann (1963) classified Lark Sparrows as an uncommon host of cowbird eggs. Conversely, in Kansas, Hill (1976) classified Lark Sparrows as a moderate or heavy acceptor of cowbird eggs. At the University of Oklahoma Biological



Station, Wiens (1963) reported a 19.0% brood parasitism rate of Lark Sparrow nests, whereas Newman (1970) reported a 45.5% brood parasitism rate. A wide range of parasitism rates was also documented in Louisiana (0%), Nebraska (20%), Missouri (20%), Kansas (20.0-81.8%), and Oklahoma (5.9-75.0%; Wiens 1963, Ortega 1998). In Oklahoma, most parasitized Lark Sparrow nests were along edges of scrub-shrub habitat adjacent to open areas (Wiens 1963). A greater percentage (63.6%) of Lark Sparrow nests in open areas and on the ground were parasitized than above ground nests (36.4%; Newman 1970). Lark Sparrow nest success was 44.5% for nests built above ground and 23.7% for nests built on the ground (Newman 1970).

Little data have been published on the relationship between microhabitat characteristics and Lark Sparrow nest success. In western Oklahoma, nest placement near structural cover was the most important microhabitat variable for Lark Sparrows (Lusk *et al.* 2003). Structural cover, such as woody herbaceous plants, may help limit thermal fluctuations during the nesting cycle (Lusk *et al.* 2003). Human alteration and fragmentation of local landscapes, including agro-conversion and urban sprawl, may lead to suboptimal nest site availability (Lusk *et al.* 2003). Lark Sparrows have been observed in cemeteries during the nesting season in south-central Oklahoma (G. Akin, pers. obs.).

Our objectives were to: 1) determine Lark Sparrow abundance and density in cemeteries, 2) determine Lark Sparrow nest success in cemeteries, 3) document Brown-headed Cowbird brood parasitism rates and effects on Lark Sparrow nests, 4) assess microhabitat characteristics of Lark Sparrow nest sites, and 5) determine the relationship between Lark Sparrow nest success and microhabitat characteristics.

## METHODS

We selected two cemeteries in southern Oklahoma to study Lark Sparrow ecology. We chose two cemeteries based on observations of Lark Sparrows use in previous years (G. Akin, pers. obs.). The Coalgate Cemetery (8.7 ha) is located 2.5 km north of Coalgate, Coal County, Oklahoma (14S 755575E 3828031N). This cemetery is dominated by Bermuda grass (*Cynodon dactylon*) with a few scattered trees including loblolly pine (*Pinus taeda*) and eastern red cedar. The eastern boundary is bordered by a paved county road with the other boundaries bordered by pasture and Crosstimbers forest composed of post oak and blackjack oak (*Quercus marilandica*) savanna. Paved roads provide access to interior portions of the cemetery which include an equipment storage shed and a pavilion.

The Highland Cemetery (28.6 ha) is located on the southeast edge of Durant, Bryan County, Oklahoma (14S 741905E 3762484N). This plot is dominated by Bermuda grass with scattered trees including eastern red cedar and water oak (*Quercus nigra*). The western and southern edges are bordered by a paved city road. The east side of this plot is bordered by land under development for a local park. Paved roads provide access to the interior of the cemetery, which includes two structures and a pavilion. Both cemeteries are maintained by regular mowing and mechanical edging.

We conducted modified, point-centered, fixed-radius point counts from 18 April to 15 July 2015 and 2016 (Hutto *et al.* 1986, Robbins *et al.* 1986, Ralph *et al.* 1993). Nine point count locations were established including three at Coalgate Cemetery and six at Highland Cemetery. Point count locations were generated within a GIS environment using the Create Random Points tool in ArcMAP 10.3 (ESRI 2014). The centers of all points were >100 m apart and >50 m from study plot boundaries (Figures 1-2).

Point counts were conducted weekly at each study plot for the duration of the study. During point counts, we counted only Lark Sparrows and Brown-headed Cowbirds. We counted Brown-headed Cowbirds to determine the abundance of this brood parasite of Lark Sparrow nests. All bird detections were spot-mapped to increase accuracy and reduce overestimation. Point count surveys were conducted between 15 min after sunrise to 1100 h (Ralph *et al.* 1993) and each point was sampled weekly. Points were sampled 13 times each year of the study. A one-minute settling period was utilized after arrival at each point to allow birds to settle post-disturbance (Ralph *et al.* 1993). Each point was conducted for five minutes by a single observer (G. Akin). Target species were identified by song or visual observation within a 50-m radius from each point (Hutto *et al.* 1986). Due to open habitat, we considered detection accuracy to be high, although we did not calculate detection probabilities. The order in which study plots and point counts were sampled was rotated weekly. We used a Kestrel Meter 2000TM weather unit (Nelson-Kellerman, Boothwyn, Pennsylvania) to record temperature and wind speed.

Lark Sparrow abundance was defined as the number of individuals



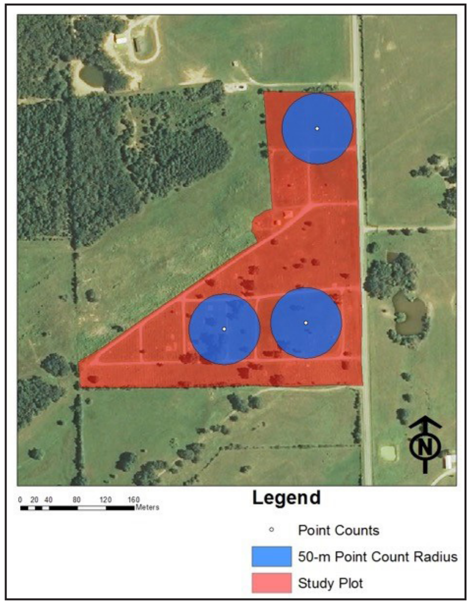


**Figure 1. Coalgate Cemetery point count locations.**

recorded per point, and averaged over the number of points per season and combined for both years of the study. We calculated mean Lark Sparrow density per 40 ha for comparison to previous studies (Walcheck 1970, Stewart and Kantrud 1972). To obtain this estimate, we extrapolated the mean density per 40 ha estimate from the mean density per point for each study plot combined.

We conducted nest searches systematically in all study plots to find active Lark Sparrow nests from 25 April to 15 July 2015 and 2016. Transects were searched for nests in each cemetery and opportunistically during point counts. Behavioral cues (e.g., territorial behavior, carrying nesting material or food items), nesting behavior, and alarm calls were used to locate nests (Ralph *et. al.* 1993, Reinking 2004). Nests were georeferenced with a hand-held Global Positioning System unit.

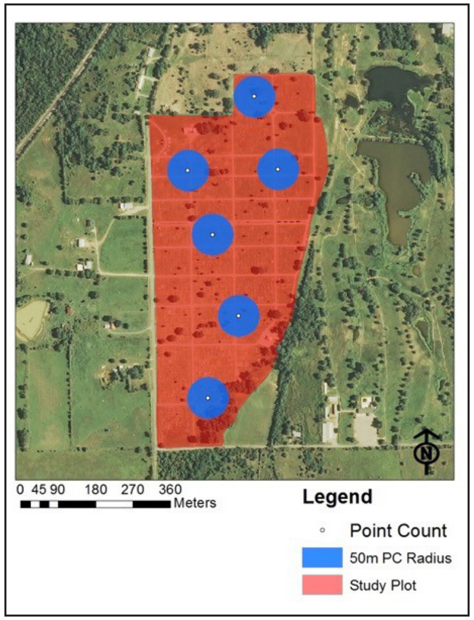


**Figure 2. Highland Cemetery point count locations.**

Nests were checked every 3-4 days to monitor status, then more frequently as each nest approached fledging (Wood and Reasor 2006). Parameters such as nest height, clutch size, and number of young fledged were recorded. Nest success was defined as a nest fledging ≥1 young (Wood and Reasor 2006). The presence of any Brown-headed Cowbird eggs or young was recorded. Nest loss events were recorded and we attempted to classify nest loss causes such as depredation, weather events, anthropogenic causes (e.g., people removing nests from ornamental flowers on headstones), or nest abandonment. Nest height was measured to the nearest cm.

Vegetation sampling was conducted at each nest site to classify Lark Sparrow nesting habitat in order to test hypotheses about microhabitat variables and nest success. We measured microhabitat variables including overhead canopy cover, horizontal vegetation density, percent ground covers, number of stems of woody vegetation, and canopy height for each point. Each paired vegetation sampling point was selected by using a randomly-generated compass bearing and random distance ≤6.6 m from each nest location based on nest territory size calculated by Fitch (1958).

We used a concave spherical densiometer to estimate percentage of overhead canopy cover at each vegetation sampling point, with readings taken in each of the four cardinal directions then averaged (Cook *et al.* 1995). We measured horizontal understory vegetation density at each sampling point using a modified Nudds board (0.3 x 1.8 m). Measurements were taken at a distance of 5 m at the four cardinal directions from each sampling point then averaged (Nudds 1977).

We used a Daubenmire square (1-$m^2$) to visually estimate the percent ground cover of grasses, forbs, sedges, woody vegetation, bare ground, and artificial material (Daubenmire 1959). Artificial material was defined as grave markers, cement roads, and artificial flowers. We counted the number of tree stems ≥10 cm diameter-at-breast-height (dbh) within a 6.6-m radius of each sampling location (Fitch 1958). Canopy height of trees at sampling sites was measured with a telescoping measuring rod to the nearest cm. Trees with a dbh ≥10 cm within a 6.6-m radius of each sampling location were measured at the highest point. If multiple trees with ≥10 cm dbh were located in the sample plot, the mean height was used for statistical analysis.

All statistical tests were conducted using SPSS Statistics 22 with an *a priori* alpha level of 0.05. Independent t-tests were used to detect differences in abundance and density (Zar 1999). We used Shapiro-Wilk's and Kolmogorov-Smirnov tests to test for normality (Zar 1999). We used Levene's test to test heterogeneity of variance (Zar 1999). If data failed tests for normality or homogeneity of variance, then nonparametric Mann-Whitney U tests were used (Zar 1999).

We used logistic regression to examine the relationship between



nest success or failure and microhabitat variables including canopy cover, horizontal vegetation density, ground covers, number of tree stems ≥10 cm dbh, canopy height, and nest height. We used linear regression to examine the relationship between the same microhabitat variables and the number of young fledged. Stepwise variable selection was used to determine microhabitat variables included in regression models, with post hoc cross classification procedures to assess model efficacy. A $x^2$ test was conducted to determine if nest height was related to nest success. An independent samples t-test was used to determine if nest height differed between years. A nonparametric Kruskal Wallis test was used to test for differences between years and cemeteries for microhabitat variables.

We calculated descriptive statistics including mean, SD, and range for nest success parameters including clutch size, number hatched, and number fledged. We used independent t-tests to compare means for each nest parameter between years. We used a $x^2$ test to compare nest success percentages between years.

## RESULTS

Between cemeteries, Lark Sparrow mean abundance was greater in Coalgate Cemetery than Highland Cemetery in 2015 ($t$ = 2.31, $df$ = 1, $P$ = 0.03) and 2016 ($t$ = 3.27, $df$ = 1, $P$ < 0.01; Table 1). Though mean abundance was numerically greater in 2015 than 2016 in Coalgate Cemetery, there was no statistical difference between years ($t$ = 1.53, $df$ = 1, $P$ = 0.13; Table 1). Mean abundance in Highland Cemetery was greater in 2015 than 2016 ($t$ = 2.09, $df$ = 1, $P$ = 0.04; Table 1).

**Table 1. Lark Sparrow abundance (mean ± SD) and density (mean/40 ha) in southern Oklahoma, 2015-2016.**

| | 2015 | 2016 | 2015-2016 |
|---|---|---|---|
| **Abundance** | | | |
| Coalgate Cemetery | 1.53 (1.35) | 1.06 (0.86) | 1.29 (1.33) |
| Highland Cemetery | 0.83 (1.04) | 0.51 (0.76) | 0.67 (0.93) |
| **Density** | | | |
| Coalgate Cemetery | 78.3 | 53.2 | 65.8 |
| Highland Cemetery | 38.9 | 26.2 | 32.6 |

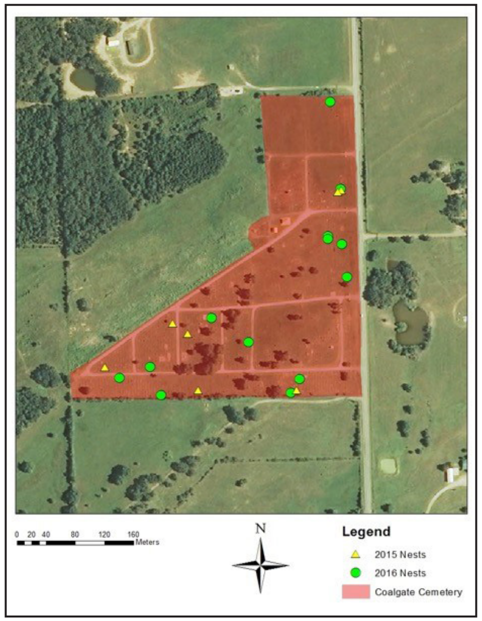


**Figure 3. Lark Sparrow nest locations, Coalgate Cemetery, 2015-16.**

In 2015, Lark Sparrow density was 52.2/40 ha for combined cemetery plots, but was lower (35.2/40 ha) in 2016. In 2015, Coalgate Cemetery Lark Sparrow density was 78.3/40 ha, which was nearly twice that of Highland Cemetery Lark Sparrow density at 38.9/40 ha (Table 1). In 2016, Coalgate Cemetery density was 53.2/40 ha and Highland Cemetery density was 26.2/40 ha (Table 1).

We located 31 nests (2015, $n$ = 9; 2016, $n$ = 22; Figures 3-4). For 2015 and 2016, mean clutch size was 3.2 eggs/nest (Table 2). In 2015, Lark Sparrow nests had a mean clutch size of 3.7 eggs/nest; however, clutch size (3.1 eggs/nest) was lower in 2016 (Table 2). There was no difference between clutch sizes in 2015-16 ($t$ = 1.69, $df$ = 1, $P$ = 0.10). In 2015, mean clutch size for Coalgate Cemetery was 3.7 eggs per nest and 3.5 eggs/nest for Highland Cemetery (Table 2). There was no difference in clutch size between Coalgate Cemetery and Highland Cemetery in 2015 ($U$ = 5.50, $df$ = 1, $P$ = 0.59). In 2016, mean Lark Sparrow clutch size was lower in Coalgate Cemetery (2.9 eggs/nest) and Highland Cemetery (3.3 eggs/nest; Table 2). There was no difference in clutch size between Coalgate Cemetery and Highland Cemetery in 2016 ($U$ = 40.0, $df$ = 1, $P$ = 0.19). For 2015-2016, mean number

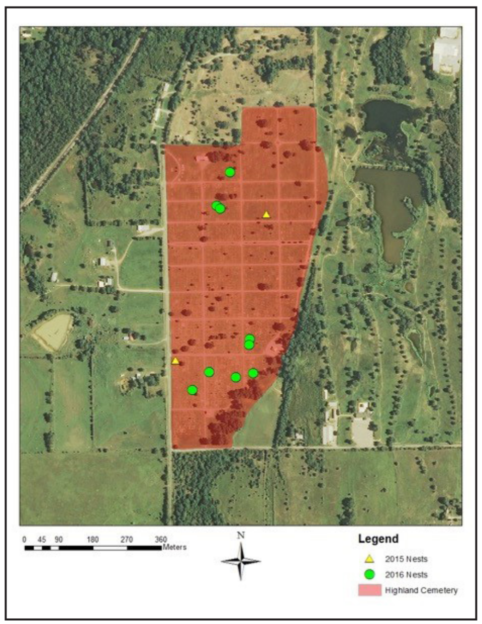


**Figure 4. Lark Sparrow nest locations, Highland Cemetery, 2015-16.**



**Table 2. Lark Sparrow mean clutch size (± SD, *n*), mean number of eggs hatched, and mean number of young fledged in southern Oklahoma, 2015-2016.**

| Nest Parameter | 2105 | 2016 | 2015-2016 |
|---|---|---|---|
| **Clutch Size** | | | |
| Coalgate Cemetery | 3.7 (0.49, 7) | 2.9 (1.2, 13) | 3.2 (1.1, 20) |
| Highland Cemetery | 3.5 (0.71, 2) | 3.3 (0.71, 9) | 3.4 (0.67, 11) |
| Combined | 3.7 (0.50, 9) | 3.1 (1.1, 22) | 3.2 (0.96, 31) |
| **Number Eggs Hatched** | | | |
| Coalgate Cemetery | 2.0 (1.7, 7) | 1.2 (1.6, 13) | 1.5 (1.7, 20) |
| Highland Cemetery | 3.0 (1.4, 2) | 1.4 (1.2, 9) | 1.7 (1.4, 11) |
| Combined | 2.2 (1.6, 9) | 1.3 (1.5, 22) | 1.6 (1.6, 31) |
| **Number Fledged** | | | |
| Coalgate Cemetery | 1.6 (1.8, 7) | 1.2 (1.6, 13) | 1.3 (1.7, 20) |
| Highland Cemetery | 2.0 (2.8, 2) | 0.7 (1.0, 9) | 0.9 (1.4, 11) |
| Combined | 1.7 (1.9, 9) | 1.0 (1.4, 22) | 1.1 (1.6, 31) |

of Lark Sparrow eggs hatched was 1.6/nest (Table 2). The mean number of eggs hatched in 2015 was 2.2/nest, but was lower in 2016 (1.3/nest; Table 2). Though number of eggs hatched was lower in 2016, there was no significant difference in number of eggs hatched between years ($t$ = 1.59, $df$ = 29, $P$ = 0.12). Mean number of Lark Sparrows hatched in Coalgate Cemetery in 2015 was 2.0/nest and 3.0/nest in Highland Cemetery (Table 2). There was no significant difference in the number of eggs hatched in cemetery plots in 2015 ($U$ = 4.5, $df$ = 8, $P$ = 0.45). In 2016, mean number of eggs hatched at Coalgate Cemetery was 1.2/nest, whereas in Highland Cemetery, mean number of eggs hatched was 1.4/nest (Table 2). There was no significant difference in the mean number of eggs hatched in cemetery plots in 2016 ($U$ = 48.0, $df$ = 21, $P$ = 0.46).

Lark Sparrows fledged ≥1 young from 56% of nests located in 2015 (Table 2). In 2015, the mean number of young fledged was 1.7/nest (Table 2). Lark Sparrows fledged ≥1 young from 41% of nests located in 2016 ($n$ = 22). Mean number of young fledged in 2016 was 1.0/nest (Table 2). There was no significant difference between years and the number of young fledged ($U$ = 78.0, $df$ = 30, $P$ = 0.32). Mean number of young fledged in Coalgate Cemetery was 1.3/nest for 2015-16, whereas Highland Cemetery fledged 0.9/nest for 2015-16 (Table 2). There was no significant difference in mean number of young fledged between cemeteries in 2016 ($U$ = 49.50, $df$ = 21, $P$ = 0.5).

Of the 31 nests located, 17 (54.9%) failed (Table 3). Seven nests were lost to unknown causes, with no fledging possible. We speculate these nests were lost due to abandonment or avian and reptilian predators that typically do not disrupt the nest during predation. Four nests were lost due to anthropogenic causes, specifically, removal of floral arrangements. Two nests were destroyed with remains of the nestlings located at the nest site, although we do not know the cause of these two nest losses. A single nest was lost due to red imported fire ant predation. Three nests were lost due to weather factors including high winds or flooding of the nest site.

We documented one cowbird brood parasitism event in 2015. The nest contained four Lark Sparrow eggs and three cowbird eggs. No cowbird eggs hatched; however, one Lark Sparrow successfully hatched and fledged. Hatching of the remaining Lark Sparrow eggs and the cowbird eggs is unknown; however, after the hatching date, all remaining eggs or possible hatchlings were absent. In 2016, we documented two brood parasitism events. The first nest had a clutch of four Lark Sparrow eggs and one cowbird egg. One Lark Sparrow hatched and one cowbird hatched. There were no fledglings from this nest due to nest predation by an unidentified predator. The second nest had a clutch of three Lark Sparrow eggs and one cowbird egg. No eggs hatched from this nest due to nest abandonment.

Grasses composed the majority of vegetation around nest sites, with only a 2% difference between years (Table 4). Sedges and forbs composed the least amount of vegetation measured at nest locations

**Table 3. Cause-specific nest loss for 17 Lark Sparrow nests in two cemetery study sites in southern Oklahoma, 2015-2016.**

| Cause | 2015 ($n$ = 4) | 2016 ($n$ = 13) | 2015-2016 ($n$ = 17) |
|---|---|---|---|
| Unknown[1] | 1 | 6 | 7 |
| Anthropogenic | 2 | 2 | 4 |
| Predation[2] | 0 | 3 | 3 |
| Weather | 1 | 2 | 3 |
| Total | 4 | 13 | 17 |

[1] Suspected avian or snake predators and abandonment.
[2] Two nests lost to suspected raccoon predation and one to red imported fire ants.



(Table 4). Artificial material percentages and understory vegetation density were equal for both years (Table 4). Bare ground and canopy cover were both greater in 2015 than 2016 (Table 4), although within 2% of each other.

**Table 4. Mean values (± SD, range) for microhabitat variables at Lark Sparrow nest locations in cemeteries in southern Oklahoma, 2015-2016.**

| Microhabitat Variable | 2015 | 2016 | 2015-2016 |
|---|---|---|---|
| Nest Height (cm) | 52.2 (30.7, 0.0-80.0) | 36.1 (43.5, 0.0-110.0) | 40.8 (40.4, 0.0-110.0) |
| % Grasses | 78.17 (8.87, 67.6-94.5) | 80.06 (5.90, 70.6-89.6) | 79.51 (6.79, 67.6-94.5) |
| % Sedge/Forbs | 1.22 (1.62, 0.0-4.2) | 2.063 (1.63, 0.2-4.8) | 1.81 (1.64, 0.0-4.8) |
| % Artificial Material | 14.56 (8.33, 0.2-29.0) | 14.73 (5.73,1.5-23.9) | 14.68 (6.44, 0.2-29.0) |
| % Bare Ground | 5.48 (2.91, 2.1-10.9) | 3.15 (2.49, 0.1-7.4) | 3.83 (2.78, 0.1-10.9) |
| % Canopy Cover | 3.97 (7.39, 0.0-19.2) | 1.67 (3.46, 0.0-12.1) | 2.33 (4.91, 0.0-19.2) |
| % Horizontal Vegetation | 16.14 (10.90, 2.9-32.8) | 16.96 (12.66, 1.7-42.1) | 16.72 (12.0, 1.7-42.1) |

There was no difference in the percentage of grasses between cemeteries in 2015 ($x^2$ = 3.1, $df$ = 1, $P$ = 0.21). There was a difference in grass percentages between cemeteries in 2016 ($x^2$ = 13.57, $df$ = 1, $P$ < 0.01) and in 2015 and 2016 combined ($x^2$ = 13.89, $df$ = 1, $P$ < 0.01). In 2015, there was no difference in percentage of sedges and forbs ($x^2$ = 1.76, $df$ = 1, $P$ = 0.42) compared to a difference in 2016 ($x^2$ = 13.57, $df$ = 1, $P$ = 0.01) and 2015-16 combined ($x^2$ = 8.23, $df$ = 1, $P$ = 0.02). There was no difference for percentage of bare ground between cemeteries in 2015 ($x^2$ = 3.58, $df$ = 1, $P$ = 0.17), 2016 ($x^2$ = 2.05, $df$ = 1, $P$ = 0.36), and 2015-16 combined ($x^2$ = 4.33, $df$ = 1, $P$ = 0.12). Percentage of canopy cover was different in 2015 ($x^2$ = 6.13, $df$ = 1, $P$ = 0.04) and 2015-16 combined ($x^2$ = 10.07, $df$ = 2, $P$ = 0.01), but was not different in 2016 ($x^2$ = 4.53, $df$ = 1, $P$ = 0.10). Horizontal vegetation density was different between cemeteries in 2015 ($x^2$ = 9.19, $df$ = 1, $P$ = 0.01), 2016 ($x^2$ = 9.02, $df$ = 1, $P$ = 0.01), and 2015-16 combined ($x^2$ = 18.60, $df$ = 1, $P$ < 0.01).

A relationship existed between nest success and microhabitat variables ($x^2$ = 14.81, $df$ = 2, $P$ < 0.01). Nest success was related to increased nest height ($\beta$ = 4.30, $SE$ = 1.53, $df$ = 1, $P$ < 0.01) with the model correctly classifying 80.6% of successful nests. No other measured microhabitat variables predicted nest success. The number of young fledged was related to two microhabitat variables ($R^2$ adj = 0.27, $F$ =

6.61, $df = 2$, $P < 0.01$). Nest height showed a positive relationship with the mean number of young fledged per nest ($\beta = 1.66$, $t = 2.77$, $SE = 0.6$, $P = 0.01$). Additionally, a positive relationship existed between increased percentage of artificial material and the mean number of young fledged ($\beta = 0.08$, $t = 2.09$, $SE = 0.04$, $P = 0.05$).

Of the 31 nests, 12 were located on the ground and 19 were above the ground. Nests located above ground had a greater success rate of 57.9% compared to 16.7% for nests located on the ground ($x^2 = 31.9$, $df = 9$, $P < 0.01$). For 2015-16, mean nest height was 40.8 cm (Table 4). Mean nest height in 2015 was 52.2 cm and 36.1 cm in 2016 (Table 4). There was no difference in nest height between years ($t = 1.01$, $df = 1$, $P = 0.32$). For 2015-2016, mean nest height was 53.5 cm in Coalgate Cemetery and 17.7 cm in Highland Cemetery.

## DISCUSSION

Mean Lark Sparrow abundance in our study was greater than in previous studies, despite habitat heterogeneity in grassland areas and anthropogenic disturbance in cemeteries (Askins 1993). Jones and Bock (2002) documented lower abundance (0.27/point) in Colorado, possibly related to urban habitat conversion and increased induced edge. Though Lark Sparrows used available habitat in coastal southern California, edge effect due to habitat fragmentation, led to decreased abundance (0.12/point) than in our study (Bolger *et al.* 1997). In southern California, Lark Sparrows were detected more frequently in large patches (50 – 400 ha) of suitable habitat dominated by coastal sage scrub, chamise chaparral, and mixed chaparral (Bolger *et al.* 1997). Lark Sparrow abundance in Comanche County, Kansas was 0.04/point in areas where less vegetation heterogeneity occurred (Hickman *et al.* 2006).

For 2015 and 2016, Lark Sparrow mean abundance at Coalgate Cemetery was twice that of Highland Cemetery, although Coalgate Cemetery was smaller than Highland Cemetery. Differences in the surrounding landscape appeared to have had an impact on mean abundance between the two study plots. Coalgate Cemetery was less disturbed by anthropogenic activity, such as interment and grave site visitation, than Highland Cemetery. Coalgate Cemetery also is more rural and bordered by agricultural fields. Conversely, Highland Cemetery is located on the edge of Durant, and has experienced more anthropogenic development with concurrent habitat loss. Lark Sparrow abundance may be lower due to edge avoidance and lack of suitable habitat in the landscape context of this site (Jones and Bock 2002). This is similar to



decreases in abundance in Colorado, where Lark Sparrows were less abundant in areas with edge adjacent to urban areas than areas with more natural habitat (Bock *et al.* 1999).

Lark Sparrow mean abundance was higher in 2015 than 2016 in both cemeteries. In 2015, high levels of rainfall in southern Oklahoma led to extensive flooding that might have contributed to more concentrated areas of abundance. Both cemetery plots had episodic flooding, causing large areas of standing water in areas that typically were used by Lark Sparrows. The decrease in available habitat due to flooding may have increased invertebrate abundance in non-flooded areas within plots that may have increased detections in 2015 compared to 2016 (Polis *et al.* 1997).

From 1977 to 1979, Rotenberry and Wiens (1980) documented a density of 12-112 Lark Sparrows/40 ha in Nevada and Oregon. We documented a density of 52.2/40 ha (2015) and 35.2/40 ha (2016). Rotenberry and Wiens (1980) also observed variability for density among years due to annual redistribution of Lark Sparrows within the landscape. Walcheck (1970) documented 5-40 pairs/40 ha in Montana, attributing low pair density to heavy grazing pressure, whereas pair density was greater in areas with less grazing pressure. Both previous studies with wide ranges of Lark Sparrow density were conducted using a transect method of sampling as opposed to point counts (Walcheck 1970, Rotenberry and Wiens 1980). In addition to using transect methods for sampling, each study conducted fewer surveys than in our study, which could have accounted for the wide range in densities (i.e., increased variation).

Lark Sparrow density at Coalgate Cemetery (65.8/40 ha) was nearly double the density in Highland Cemetery (32.6/40 ha). Habitat structure surrounding each cemetery likely contributed to Lark Sparrow density in each plot. Coalgate Cemetery has more agricultural fields, grasslands, and less urban interface than Highland Cemetery. Avoidance of edges and anthropogenic disturbance in Highland Cemetery might explain the variation in density between cemeteries (Jones and Bock 2002).

McNair (1985) reported Lark Sparrow mean clutch size of 4.09 eggs/nest from museum collection oology cards and 3.84 eggs/nest from nest record cards. Though McNair (1985) used data from numerous sources throughout the species' range, the majority of data were from California and Texas. Newman (1970) reported a mean clutch size of 3.4 eggs/nest in southern Oklahoma. We documented similar mean clutch size (3.2) in cemeteries. We also documented variation in annual mean clutch size between 2015 and 2016. Although there was no statistical difference in clutch size between 2015 (3.7) and 2016 (3.1), the loss of 0.6 eggs/clutch might have biological significance related to long-term population dynamics. Annual variation in clutch size might have been due to changes in food availability, although we did not sample potential prey abundance (Nur 1986). A possible increase in food availability, due to increased precipitation in 2015, may have increased fitness in female Lark Sparrows, resulting in larger clutch sizes (Price and Liou 1989). In 2016, Coalgate Cemetery mean clutch size was nearly one egg/nest less than 2015 and Highland Cemetery mean clutch size had 0.2 eggs/nest less than 2015. The greater reduction in clutch size in Coalgate Cemetery might be attributed to annual variation in invertebrate abundance, precipitation, or increased anthropogenic loss.

In 2015 and 2016, Lark Sparrows had a small number of eggs that did not hatch due to unknown causes (e.g., infertile eggs, incomplete development). Unhatched eggs are common in birds and are caused by death of the embryo or an unfertilized egg (Birkhead *et al.* 1994, Birkhead *et al.* 2008). Koenig (1982) listed season, age of parents, clutch size, and population density as additional factors that influence egg hatchability. We documented no statistical difference between years for the number of eggs hatched per nest, but the decrease of 0.9 young hatched/nest may be important to Lark Sparrow population dynamics.

The mean number of young fledged in southern Oklahoma was 1.7 and 1.0 young/nest in 2015 and 2016 respectively. Our data was similar to Newman's (1970) fledging rate of 1.2 young/nest and slightly higher than Wiens (1963) fledging rate of 1.0 young/nest in southern Oklahoma. Though more nests were located in 2016, Lark Sparrows fledged fewer young/nest that year. Greater amounts of rain in 2015 might have contributed to an increase in invertebrate prey availability, thereby improving survival of young. Annual variation was also a likely factor in the difference of mean number of young fledged between years. Concomitant with fewer young fledged/nest, nest success went from 56% in 2015 to 41% in 2016. Though there was a 15% difference in nest success between 2015 to 2016, nest success in our study was greater than that reported in previous studies. Wiens (1963) documented Lark Sparrow nest success of 26.3% and Newman (1970) documented Lark Sparrow nest success of 42%.

Anthropogenic factors (e.g., collisions with buildings, predation by free-roaming pets, pollution) negatively affect avian populations annually (Loss *et al.* 2012). Anthropogenic factors (e.g., removal of floral arrangements, mowing) contributed to 12.9% of nest losses in 2015-16. Removal of floral arrangements by cemetery visitors or destruction



of active nests by mowing and edging activity was greater in 2016 than 2015. Weather events contributed to nest loss in 2015-16. Nests were lost in 2015 due to high winds dislodging flower arrangements where nests were located. Skagan and Adams (2012) documented that intense daily precipitation could result in lower survival of Lark Bunting (*Calamospiza melanocorys*) nests in Colorado. In addition, Etterson *et al.* (2007) reported Loggerhead Shrikes (*Lanius ludovicianus*) were more likely to experience nest failure due to extreme weather events (e.g., heavy rainfall, high winds) in Comanche County, Oklahoma. We documented similar results in 2016 with one nest lost due to flooding at the nest site after heavy rains.

We documented 9.7% nest loss due to predation for all nests compared to 38.7% by Newman (1970). The difference in nest loss is likely due to differences in classifying nest loss as unknown in our study that Newman (1970) may have classified as suspected snake predation. Newman (1970) documented four nests lost due to suspected mammalian predators, compared to two nests lost in our study. Though the identification of the suspected mammal could not be confirmed, the extent of destruction of the nest site likely indicated a mammalian predator (Newman 1970).

Newman (1970) documented eight nests lost due to possible snake predation. We did not confirm any specific cases of snake predation on Lark Sparrow nests. Brush and Ferguson (1986) documented a massasauga rattlesnake eating Lark Sparrow eggs from a nest in Kansas. Avian predators should also be considered in cases of nest loss (Burger *et al.* 1995, Staller *et al.* 2005). Stake *et al.* (2004) documented American Crows (*Corvus brachyrhynchos*) eating eggs and nestlings from Golden-cheeked Warbler nests (*Setophaga chrysoparia*) in Texas, a species with similar shrub-ground nesting behavior. In areas with edge-dominated landscapes and urbanization, avian nest predators such as Cooper's Hawk (*Accipiter cooperii*), owls, American Crow, Blue Jay (*Cyanocitta cristata*) and Common Grackle (*Quiscalus quiscula*) are more abundant, which could lead to increased nest loss due to predation (Wilcove 1985). We documented a single nest lost to red imported fire ants. Red imported fire ants are known to be detrimental to nesting birds such as Northern Bobwhite (*Colinus virginianus*) and Black-capped Vireo (*Vireo atricapilla*) (Allen *et al.* 1995, Mueller *et al.* 1999).

Friedmann (1963) described Lark Sparrows as an uncommon acceptor of cowbird eggs; however, extensive variation has been reported for brood parasitism rates of Lark Sparrow nests. Newman (1970) reported 45.5% of Lark Sparrow nests were parasitized by cowbirds in southern Oklahoma. Conversely, Wiens (1963) reported only 19% brood parasitism of Lark Sparrow nests in southern Oklahoma. We recorded a 9.5% brood parasitism rate of nests in our study. Habitat differences between our study plots and the study plots used in previous studies may have contributed to reduced brood parasitism rates. Cemeteries are regularly maintained to reduce vegetation height which could make it more likely for cowbirds to locate nests; however, maintenance also removes habitat structures that female cowbirds might use to conceal themselves while attempting to parasitize a nest. Habitat manipulation in cemeteries could explain the difference in brood parasitism events between our study and previous studies. Wiens (1963) and Newman (1970) conducted their research at the University of Oklahoma Biological Station with different results in brood parasitism rates. Urbanization increased, whereas agricultural activity decreased in the surrounding landscape. Habitat surrounding their site also underwent secondary succession providing more favorable habitat such as dense understory and increased edge for cowbirds to parasitize nests.

In our study, nests were frequently built above ground in artificial flower arrangements. Nest site placement in artificial flowers provided dense cover for concealment from predators and cowbirds. The use of artificial flowers by Lark Sparrows may mimic the use of short, dense woody vegetation or grass clumps in undisturbed habitat (Newman 1970). An increased percentage of artificial material at nest sites was a predictor of number of young fledged according to our regression models.

In western Oklahoma, Lusk *et al.* (2003) documented an increase in Lark Sparrow nest success in areas with low percentages of bare ground and litter cover, as well as higher nest success associated with a greater percentage of structural cover at the nest site. Lusk *et al.* (2003) also noted that Lark Sparrow nest placement may be more related to microclimate than concealment from predators. Our results indicated a positive relationship to nest height and percentage of artificial material at the nest site. Lack of a significant relationship between Lark Sparrow nest success with percentage of grasses, sedge/forbs, canopy cover, or horizontal vegetation might be due to habitat homogeneity created by habitat maintenance in cemeteries where nests were located.

Nest height was the most important predictive factor in Lark Sparrow nest success in cemeteries. Nests built above ground level had a 57.9% chance of fledging young compared to a 16.7% chance for nests located at ground level. Nests located above ground level were located in flower arrangements on grave markers, although using ornamental flowers for nest sites presented problems native vegetation may not. Anthropogenic removal of flower arrangements at grave sites caused nest loss. In addition, we documented that four nests located in ornamental flowers were lost due to high winds. Nests built at ground level in cemeteries experienced an increased chance of nest loss due to depredation compared to those located above ground. Nest predation may increase with increased edge effect caused by urbanization and agricultural use (Newman 1970, Wilcove 1985). In addition, risk of ground nest loss due to mowing and landscaping activity in cemeteries was more likely.



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## LITERATURE CITED

Allen, R., S. Lutz, and S. Demarais. 1995. Red imported fire ant impacts on northern bobwhite populations. Ecological Application 5:632–638.

Askins, R. A. 1993. Population trends in grassland, shrubland, and forest birds in eastern North America. Current Ornithology 11:1–34.

Baumgartner, F. M., and A. M. Baumgartner. 1992. Oklahoma bird life. University of Oklahoma Press, Norman.

Birkhead, T. R., J. Hall, E. Schut, and N. Hemmings. 2008. Unhatched eggs: methods for discriminating between infertility and early embryo mortality. Ibis 150:508–517.

Birkhead, T. R., B. C. Sheldon, and F. Fletcher. 1994. A comparative study of sperm-egg interactions in birds. Functional Ecology 10:375–383.

Bock, C. E., J. H. Bock, and B. C. Bennett. 1999. Songbird abundance in grasslands at a suburban interface on the Colorado high plains. Studies in Avian Biology 19:131–136.

Bolger, D. T., T. A. Scott, and J. T. Rotenberry. 1997. Breeding bird abundance in an urbanizing landscape in coastal Southern California. Conservation Biology 11:406–421.

Brush, S. W., and G. W. Ferguson. 1986. Predation on Lark Sparrow eggs by a massasauga rattlesnake. Southwestern Naturalist 31:260–261.

Burger, L. W., T. V. Dailey, E. C. Kurzejeski, and M. R. Ryan. 1995. Survival and cause-specific mortality of northern bobwhites in northern Missouri. Journal of Wildlife Management 59:401–410.

Cook, J. G., T. W. Stutzman, C. W. Bowers, K. A. Brenner, and L. L. Irwin. 1995. Spherical densiometers produce biased estimates of forest canopy cover. Wildlife Society Bulletin 23:711–717.

Daubenmire, R. F. 1959. Canopy coverage method of vegetation analysis. Northwest Science 33:43–46.

ESRI. 2014. ArcGIS Desktop; Release 10.3. Redlands, CA: Environmental Systems Research Institute.

Etterson, M. A., L. R. Nagy, and T. R. Robinson. 2007. Partitioning risk among different causes of nest failure. Auk 124:432–443.

Fitch, H. S. 1958. Home ranges, territories, and seasonal movements of vertebrates of the natural history reservation. University of Kansas Museum of Natural History Miscellaneous Publication 11:63–326.

Friedmann, H. 1963. Host relations of the parasitic cowbirds. United States National Museum Bulletin 233:1–276.

Hickman, K. R., G. H. Farley, R. Channell, and J. E. Steier. 2006. Effects of Old World bluestem (*Bothriochloa ischaemum*) on food availability and avian community composition within the mixed-grass prairie. Southwestern Naturalist 51:524–530.

Hill, R. A. 1976. Host-parasite relationships of the Brown-headed Cowbird in a prairie habitat of West-Central Kansas. Wilson Bulletin 88:555–565.

Hutto, R. L., S. M. Pletche, and P. Hendricks. 1986. A fixed-radius point count method for nonbreeding and breeding season use. Auk 103:593–602.

Jones, Z. F., and C. E. Bock. 2002. Conservation of grassland birds in an urbanizing landscape: a historical perspective. Condor 104:643–351.

Knopf, F. L. 1996. Prairie legacies-birds. Pages 135–148 in Prairie conservation: preserving North America's most endangered ecosystem. (F. B. Samson and F. L. Knopf, editors). Covelo, CA: Island Press.

Koenig, W. D. 1982. Ecological and social factors affecting hatchability of eggs. Auk 99:526–536.

Loss, S. R., T. Will, and P. P. Marra. 2012. Direct human-caused mortality of birds: improving quantification of magnitude and assessment of population impact. Frontiers in Ecology and the Environment 10:357–364.

Lusk, J. J., K. S. Wells, F. S. Guthery and S. D. Fuhlendorf. 2003. Lark Sparrow (*Chondestes grammacus*) nest-site selection and success in a mixed-grass prairie. Auk 120:120–129.

Martin, J. W., and J. R. Parrish. 2000. Lark Sparrow (*Chondestes grammacus*), The Birds of North America Online.



McNair, D. B. 1985. A comparison of oology and nest record card data in evaluating the reproductive biology of Lark Sparrows, *Chondestes grammacus*. Southwestern Naturalist 30:213–224.

Mueller, J. M., C. B. Dabbert, S. Demarais, and A. R. Forbes. 1999. Northern Bobwhite chick mortality caused by red imported fire ants. Journal of Wildlife Management 63:1291–1298.

Newman, G. A. 1970. Cowbird parasitism and nesting success of Lark Sparrows in southern Oklahoma. Wilson Bulletin 82:304–309.

Nudds, T. D. 1977. Quantifying the vegetative structure of wildlife cover. Wildlife Society Bulletin 5:113–117.

Nur, N. 1986. Is clutch size variation in the blue tit (*Parus caeruleus*) adaptive? An experimental study. Journal of Animal Ecology 53:479–496.

Ortega, C. P. 1998. Cowbirds and other brood parasites. The University of Arizona Press.

Polis, G. A., S. D. Hurd, C. T. Jackson, and F. S. Pinero. 1997. El Nino effects on the dynamics and control of an island ecosystem in the Gulf of California. Ecology 78:1884–1897.

Price, J. P., S. Droege, and A. Price. 1995. The summer atlas of North American birds. Academic Press, New York.

Price, T., and L. Liou. 1989. Selection on clutch size in birds. American Naturalist 134:950–959.

Ralph, C. J., G. R. Geupel, P. Pyle, T. E. Martin, and D. Desante. 1993. Handbook of field methods for monitoring landbirds. Gen. Tech. Rep. PSW-GTR-144. Albany, CA: Pacific Southwest Research Station, Forest Service, U.S. Department of Agriculture; 41 p.

Reinking. D. L. 2004. Oklahoma breeding bird atlas. University of Oklahoma Press, Norman.

Robbins, C. S., D. Bystrak, and P. H. Geissler. 1986. The breeding bird survey: its first fifteen years. 1965-1979. United States Fish and Wildlife Resource Publication 157:1–196.

Rotenberry, J. T., and J. A. Wiens. 1980. Temporal variation in habitat structure and shrubsteppe bird dynamics. Oecologia 47:1–9.

Sauer, J. R., J. E. Hines, J. E. Fallon, K. L. Pardieck, D. J. Ziolkowski, JR., and W. A. Link. 2015. The North American Breeding Bird Survey, Results and Analysis 1966–2015. Version 07.03.2013 USGS Patuxent Wildlife Research Center, Laurel, MD.

Skagen, S. K., and A. A. Y. Adams. 2012. Weather effects on avian breeding performance and implications of climate change. Ecological Applications 22:1131–1145.

Stake, M. M., J. Faaborg, and F. R. Thompson III. 2004. Video identification of predators at Golden-cheeked Warbler nests. Journal of Field Ornithology 75:337–344.

Staller, E. L., W. E. Palmer, J. P. Carroll, R. P. Thornton, and D. C. Sisson. 2005. Identifying predators at northern bobwhite nests. Journal of Wildlife Management 69:124–132.

Stewart, R. E., and H. A. Kantrud. 1972. Population estimates of breeding birds in North Dakota. Auk 89:766–788.

Sutton, G. M. 1967. Oklahoma birds: their ecology and distribution, with comments on the avifauna of the Southern Great Plains. University of Oklahoma Press, Norman.

Walcheck, K. C. 1970. Nesting bird ecology of four plant communities in the Missouri River breaks, Montana. Wilson Bulletin 82:370–382.

Wiens, J. A. 1963. Aspects of cowbird parasitism in Southern Oklahoma. Wilson Bulletin 75:130–139.

Wilcove, D. S. 1985. Nest predation in forest tracks and the decline of migratory songbirds. Ecology 66:1211–1214.

Wood, D. R., and J. A. Reasor. 2006. Prothonotary Warbler reproductive success and site fidelity in a fragmented Oklahoma landscape. North American Bird Bander 31:5–9.

Zar, J. H., 1999. Biostatical analysis. Fourth edition. Prentice Hall, Upper Saddle River, New Jersey.

Zimmerman, J. L. 1993. The birds of Konza: the avian ecology of the tallgrass prairie. Lawrence: University of Kansas Press.

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